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DR. RANSOM'S CONTRIBUTIONS TO PARASITOLOGY

W. W. Cort
Johns Hopkins University

The dedication of a number of this Journal to Dr. Brayton H. Ransom on the first anniversary of his death is an appropriate tribute to one who served for many years on its editorial board and who, before his untimely death, had come to rank as one of the world's leading parasitologists. A brief review of his published works will indicate the significant part which he played in the development of parasitology.

Doctor Ransom's published papers consisting of more than 160 titles are the fruits of a quarter of a century of intensive scientific work. From his first publication of researches completed as a graduate student at the University of Nebraska in 1900 when he was only 21 years of age, throughout the varying phases of his scientific career, his papers are characterized by a painstaking thoroughness and care in detail. This, coupled with a conservativeness in drawing conclusions and an unusual grasp of his subject, made it possible for him to leave his mark on almost every phase of the field of parasitology. Although his efforts were chiefly given to the study of worms parasitic in domesticated animals, he contributed to the understanding of the cattle ticks, and through his studies on trichinosis, tapeworms and the life cycle of Ascaris to the medical phases of parasitology.

EXTENSIVE RESEARCH ALONG VARIOUS LINES

Much of Doctor Ransom's earlier work was on the morphology and classification of cestodes and nematodes. We owe to him the descriptions of a number of new species of worms parasitic in both domesticated and wild animals. He also reported for the first time from the United States many parasites of domesticated animals already known in Europe or elsewhere. The morphological and systematic phases of his investigations probably reached their highest point in 1911 when he published the paper on the "Nematodes Parasitic in the Alimentary Tract of Cattle, Sheep and other Ruminants." This publication has had a great practical influence in systematizing our knowledge of these forms, and has set much needed standards in accuracy of detail and care in classification. Although Doctor Ransom's main interest gradually swung

away from researches of this type he continued to describe new parasites and make contributions to morphology and classification throughout the whole course of his work, as indicated by his publication in 1920 of a comprehensive systematic paper on the trematode family Heterophyidae, in which in his characteristic way he was able to bring clarity and order into a much confused group, and by a recent paper published in 1924 on the hookworms of dogs, foxes and other animals. Systematic and morphological work must form the background for the development of our knowledge of any group of animals, and along these lines the bulk of the researches in helminthology has been directed. If Doctor Ransom had done nothing else his investigations along these lines would have assured him of a place in the history of parasitology. He was not one, however, to be content with one type of activity and we soon find him engaged in experimental studies.

One of the main lines of the development of his experimental work came about through the necessity of maintaining adequate safeguards against such parasites as *Trichinella spiralis* and the large Taenias of man which are spread through the consumption of meat. The extensive experimental studies by Ransom and his co-workers on the effect of heat, cold and other agencies on the larval stages of these parasites made it possible for the government to develop adequate measures which both protect the public and take care of the interests of the meat producers. This series of researches, with requirements quite different from his previous investigations, show a clearness of insight, an ingenuity of experimentation and a sanity in the interpretation of results, which make them models of their kind.

Throughout the course of Doctor Ransom's work, he was constantly engaged in the attempt to clear up the complete life cycles of the parasitic worms with which he dealt and to solve their modes of transmission. The practical trend of his thinking and the necessities of his position kept constantly before him the need of detailed knowledge of a parasite's life-cycle in formulating adequate control measures. Some of his most brilliant researches were along this line covering such a wide range of forms as Ascaris, Haemonchus, Strongyloides, Gongylonema, Habronema, Syngamus and *Taenia ovis*. An example of this type of work is the investigation on the life cycle of *Haemonchus contortus* in which the upward migrations of the larvae were first pointed out and the adaptation of this reaction definitely established. As a further example might be mentioned the investigations on *Habronema muscae,* the results of which were published in complete form in 1913 in Bulletin No. 163 of the Bureau of Animal Industry under the title "The Life History of Habronema muscae (Carter), a Parasite of the Horse transmitted by the House Fly." This study might well be taken as a model by anyone undertaking work on nematode life

history. Starting with a thorough and critical historical analysis he proceeds through a series of morphological and biological studies of this parasite in flies to an establishment of the identity of the oldest stage found in flies with the youngest stage in horses and a detailed analysis of the developmental stages in the horses. Doctor Ransom's most recent and best known contribution to the life cycle of nematodes was on *Ascaris lumbricoides*. In an extensive series of researches on this parasite, following the earlier work of Stewart and others, he was able with the aid of his collaborators in repeated series of most critical and carefully carried out experiments to trace the details of the migrations in the body of its final host and to adequately present the true significance of these wanderings in relation to the whole life-cycle. Following this with a real conception of the important implications of this wandering phase, he was able to interpret its significance to veterinary and human medicine.

Doctor Ransom often reached out into the clinical and pathological fields of veterinary helminthology and made important contributions on the effect on the host of such parasites as *Davainea echinobothrida, Cooperia punctata, Syngamus trachea* and *Ascaris lumbricoides*. The fertility of his mind is further shown by his recent paper on "Ascaris Sensitization" in which we find him pushing out into that most important and only slightly explored field of the reactions of the host to parasitic invasion.

PRACTICAL APPLICATION OF RESULTS OF RESEARCH

Although Doctor Ransom was essentially a research man, it was necessary for him in his position as Chief of the Zoological Division of the Bureau of Animal Industry to constantly consider the applications of his discoveries and to contribute to the practical side of veterinary parasitology.

One phase of this part of his work was the education of those who were engaged in the handling of domesticated animals in the significance of the parasites which they harbor. This called for the publication from time to time of semipopular bulletins or other articles. These papers are characterized by clearness, simplicity and accuracy in detail, and are splendid examples of the possibility of the combination of popular presentation and scientific accuracy. No matter how popular the article, he always succeeded in making the subject discussed richer by his own experience and point of view. As examples of this kind of writing can be taken his chapter on the "Metazoan Parasites of Man" in Nelson's Loose-Leaf Medicine published in 1920 and his paper on "Trichinosis" in the Report of the Eighteenth Annual Meeting of the Live Stock Sanitary Association, February, 1915. In my opinion this latter is the best general discussion of trichinosis to be found in the literature.

The most important of Doctor Ransom's practical contributions were the measures which he developed for the control of certain parasites of domesticated animals, and the part which he had in the development of the proper application of these measures. His part in formulating control measures against the stomach worms of sheep has been a great aid to the sheep raising industry and through the meat inspection service he contributed largely to the basic regulations for the control of such forms as trichina and the tapeworms.

His recent development of the swine sanitation system, popularly known as the McLean County system is probably his most outstanding contribution along this line. With unusual insight he utilized the researches on the migrations of Ascaris larvae in working out a practical control system against this parasite, helped devise the details of its application and had a large part in putting it across to the farmers by embodying it in a moving picture which has been widely distributed. This achievement in the control of Ascaris is one of the best examples we have of the practical importance of detailed scientific research.

REMARKABLE VERSATILITY AS SCIENTIST

In the history of parasitology we have had great systematists, morphologists, experimentalists and practical control men, but there have been but few workers who could achieve a high position in even two of these different phases of the subject. In Doctor Ransom were combined characteristics which made it possible for him to successfully engage in any of the varying kinds of research which are needed to build up a complicated field like that of parasitology. Not only was he an outstanding systematist, morphologist and experimentalist but he had that rare power of translating his findings into popular language, and he was able to sanely and adequately apply his results in building up and carrying out programs for the control of the parasites he studied. In his death, American parasitology lost one of its foremost leaders. His twenty-five years of crowded achievement remain as a definite refutation of the archaic opinion, still too widely held by certain groups of American biologists, that there is any conflict between pure and applied science.

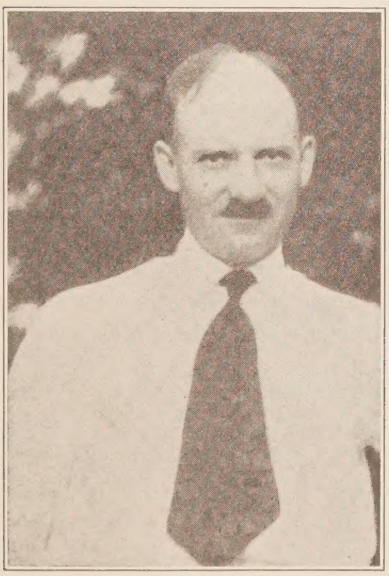
Doctor Ransom had a profound influence on those who worked in his laboratory and the younger investigators who came under his direction considered him a revered teacher and friend. Those of us who knew him well were proud to acknowledge his influence and leadership. He was an outstanding figure in American parasitology and his place in the history of the subject is assured. We are proud of his achievements and can only wonder to what heights he might have risen if he had been permitted to round out his scientific career.

DR. RANSOM AND THE BUREAU OF ANIMAL INDUSTRY

JOHN R. MOHLER
Chief, United States Bureau of Animal Industry

Dr. Brayton H. Ransom came to the Bureau of Animal Industry on June 1, 1903, as Scientific Assistant in Zoology, and on April 1, 1904, he was placed in charge of the Zoological Laboratory. On July 1, 1906, when that laboratory was made a division, he was appointed chief of the new division, where he served as a worthy successor of the eminent men who had preceded him, until his death on September 17, 1925.

Dr. Ransom had received college training under able zoologists and parasitologists at the Universities of Nebraska and Missouri, and his previous position as assistant in the Zoological Division of the Hygienic Laboratory of what was then the Public Health and Marine Hospital Service, now the U. S. Public Health Service, together with his college courses, gave him excellent opportunities and preparation for his duties in the Bureau. He was a keen observer, an excellent manipulator and most careful in analysis. One result never satisfied him; he examined and reexamined with painstaking care, and when he had finished an investigation the results were dependable. In the presentation of the theories and facts of his science, he took much pleasure. His spirit of service was far-reaching and although he delved deeply into his research work, he did not lose perspective. This admirable quality inspired confidence and enhanced the value of the results of his investigations. While his name is written large in the standard publications on parasitology, he never boasted about his accomplishments, and although he had little tolerance for sham and show, he was mild in his criticisms and rejoiced in the accomplishments and success of others. He recognized merit where he found it and jealousy was not a part of his generous nature. His ability to evaluate the efforts and power of others in the application of their intelligence to



their tasks and his admirable conception of fairness and justice, together with his wide acquaintance among the Bureau personnel and intimate knowledge of the details of the Bureau activities, made his services very valuable as a member of the committees appointed to pass on the status of employees and make recommendations affecting their rating. And on account of his recognized ability and impartiality he was selected at times to act as an arbiter in cases of dispute among scientists.

Dr. Ransom's administration of his Division in its relation to his superiors and the members of his staff was most courteous, gracious, and fair. The Zoological Division was therefore conspicuous for its high morale, efficiency, and loyalty under his able leadership. It was never a one-man laboratory; each individual member of the staff recognized his opportunities and responsibilities and knew that he would be given due credit for his efforts and accomplishments. Under such auspicious conditions his staff was gradually increased and the investigations extended to meet as many as possible of the more pressing economic problems in the field of parasitology in its relation to the livestock industry of our country. Dr. Ransom crowded into his twenty-two years of public service with the Bureau of Animal Industry more of valuable achievement than most scientists may hope for who are spared to pursue their activities to a ripe old age. Any one of several of his accomplishments would have been enough to bring glory to the life of one man. It would be impossible to evaluate in terms of dollars the service of Dr. Ransom to the livestock industry and to humanity, a service that will continue to save human lives, conserve livestock, and materially aid in developing agriculture, especially in the South.

SOME OUTSTANDING ACHIEVEMENTS

Among his bibliography of over 160 titles there are some which from the viewpoint of economic importance stand out prominently. It was Dr. Ransom who in cooperation with the workers in his Division first found in the United States many economically important parasites, contributed to our knowledge of the true causes of pathological conditions that result from infestations with *Davainea echinobothrida*, *Cooperia punctata*, *Syngamus trachea*, and *Ascaris lumbricoides;* also developed measures for the control of stomach worms in sheep, originated and developed the system of raising swine under sanitary conditions known as the McLean County System, established important fundamental facts which are contributing to our success in freeing the South of Texas-fever ticks, and did the research work on which the present meat inspection regulations are based for the protection of consumers against injurious parasites transmissible from animals to man, especially trichinæ and cysticeri.

Dr. Ransom was conspicuous among scientists not only on account of the scope comprehended in his investigations and the carefulness and thoroughness of his work, but also because he sought opportunities to apply his knowledge in a practical way. It was not uncommon for him to leave his microscope and go out in the field for weeks at a time to test under field conditions the application of the knowledge acquired in the laboratory. While he was developing the possibilities of arsenical solution as a tick destroyer, he spent much time in the field studying the effects of arsenical solution not only on ticks but also on the animals to which it was applied. As a result of the application of his studies, the less effective methods of eradication then in use were replaced by the arsenical dip which has made possible the destruction of Texas-fever ticks in the South. This was perhaps his most valuable economic contribution to our livestock industry.

Early in the history of the Bureau, investigations of trichinosis were stimulated by the restrictions which had been placed upon American pork by foreign governments because of its alleged dangerous character due to the prevalence of trichinæ in American hogs. The conditions imposed by the foreign governments which demanded a microscopic inspection of American pork before admission to foreign markets, were met. This led to repeated agitations directed toward the establishment of microscopic inspection as a routine of our Federal meat inspection, a measure which if applied to all hogs slaughtered under Federal meat inspection would be prohibitive, as it would cost more than the four and a half million dollars now appropriated for the entire meat inspection service. While the mortality among people from trichinosis was not great in this country, there was evident need of more protection of pork consumers against possible infestation. As a result of a comprehensive study of the refrigeration and thermal death points of trichinæ, together with extensive experiments to ascertain the effects on the products when pork in which they are encysted is properly cured, Dr. Ransom devised a scheme for handling meats cooked in official establishments and those prepared customarily to be eaten without cooking, which protects consumers against the danger of acquiring trichinosis from these sources. The methods devised by him have been in successful operation for several years and during this time no cases of trichinosis have been reported that could be traced to cooked products or to products customarily eaten without cooking that were prepared in establishments operating under Federal inspection, though cases traced to other sources have been reported frequently.

The present federal regulations governing methods of inspection and disposition of carcasses found affected by *Cysticercus bovis* are based on Dr. Ransom's investigations of the distribution of this parasite, its relative frequency in different portions of the carcass, and the effects of

refrigeration upon its vitality. During the past ten years the frequency of *Cysticercus bovis* among cattle slaughtered under federal inspection has materially decreased. This is undoubtedly largely the result of the efficient inspection of beef for tapeworm cysts devised by Dr. Ransom and which practically eliminates the danger of the spread of tapeworm infestation from beef slaughtered under federal inspection.

As I am writing this brief tribute to the memory of one who was a highly valued co-worker, there comes to my desk the April issue of "Meat and Live Stock Digest," which contains an article entitled "How Sanitation Improves Pig Yield." There appears in this article a number of extracts from a report on the McLean County system of swine sanitation, prepared by E. T. Robbins of the University of Illinois. The first statement that attracts my attention reads as follows: "During 1925 a total of 608 farmers in 61 counties practiced a simple system of swine sanitation on their farms with striking success. . . . A summary of their experience shows among other things that they were able to raise the usual number of pigs from one-fourth fewer sows than were necessary under the old system of raising hogs; that they raised 98% of the pigs saved at farrowing time; that there were almost no runts among the sanitation pigs, and that the pigs raised this way were heavier at four months of age, were produced more cheaply, were more uniform, and reached market earlier than pigs raised under common methods. Briefly, these results were possible because the swine sanitation system protected the young pigs from worms and necrotic infections." This quotation shows the results of the application of the knowledge Dr. Ransom acquired during his studies of the life history of *Ascaris lumbricoides*. The McLean County system of swine sanitation which is proving so beneficial to the swine industry of the country, was devised, developed, and extended by Dr. Ransom.

Prior to the investigation by Dr. Ransom, little was definitely known concerning the life history of *Haemonchus contortus*. The knowledge acquired through this investigation was applied by him in extensive tests of various methods of control in connection with the management of sheep under farm conditions to prevent stomach-worm losses among lambs. A farm near Washington, D. C., consisting of 160 acres, was leased for the purpose. When an effective system had been devised at the experiment farm, demonstrations were conducted under the supervision of the Zoological Division in a sheep-raising section of the West. The results have been eminently satisfactory and the spread of this system of treating and handling sheep will result in a great saving to the sheep growers of the country.

NATIONAL AND INTERNATIONAL AFFILIATIONS

We have mentioned some of the outstanding achievements and services of Dr. Ransom which will endure to his credit and the credit

of the Bureau with which he was connected. Under his administration the Zoological Division built up a laboratory that enjoys an enviable reputation for its large and varied contributions of both a scientific and practical nature, its very extensive collection of specimens, and the largest and finest catalogue and index of parasites in the world.

The high esteem in which he was held as a scientist and a gentleman is indicated by his affiliations with various scientific groups. He was United States delegate to the Seventh International Zoological Congress, the Fourth Fisheries Congress and the First Pan-American Scientific Congress, and a member of the editorial boards of the Journal of Parasitology and the American Journal of Tropical Medicine. He was a member of the American Microscopical Society (president), American Society of Naturalists, American Society of Zoologists, American Association for the Advancement of Science (fellow), American Society of Tropical Medicine (secretary-treasurer), American Veterinary Medical Association (honorary member), American Society of Parasitologists (councilor), Biological Society of Washington, Entomological Society of Washington, Helminthological Society of Washington (past president), Washington Academy of Sciences (vice president), Société de pathologie exotique (foreign correspondent), Reale Accademia d'Agricoltura di Torino (foreign correspondent), Phi Beta Kappa, Sigma Xi, Beta Theta Pi, and the Cosmos Club. In recognition of his work on ascarids he recently had conferred on him the gold medal of the Seamen's and Tropical Diseases Research Association of Kobe, Japan.

Dr. Ransom did not seek wealth, for he loved his science and could not be influenced to commercialize his ability and achievements. He did not seek fame, but it came to him justly through his ability, energy and application. He was a just, sympathetic, tolerant man, every ready for service. Through his death the world has lost an unusually capable scientist who left a remarkable record and a delightful memory of a noble, unselfish life.

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SOME PRACTICAL PRINCIPLES OF ANTHELMINTIC MEDICATION

MAURICE C. HALL
Chief, Zoological Division, U. S. Bureau of Animal Industry

INTRODUCTION

It is entirely appropriate that a memorial number of the Journal of Parasitology in honor of Dr. B. H. Ransom should contain a paper on anthelmintics. Dr. Ransom had done some work on anthelmintics at one time and a paper on the action of anthelmintics on parasites located outside of the alimentary canal was published by Ransom and Hall in 1912. While the subject was never one of his major projects, he was keenly interested in it and came to an early appreciation of the fact that our knowledge of these drugs was very inadequate and that much of the literature was a hodge-podge of formulae with little in it of proved value. For this reason he decided to inaugurate in the Zoological Division a project for the study of anthelmintics and in 1915 this work was begun with the present writer in charge of the project and the late W. D. Foster collaborating. Since Mr. Foster's death, Dr. J. E. Shillinger has collaborated on this project. The general plan of work along the line of what we have called critical testing was settled in conference by Dr. Ransom and the writer, and has been followed since with but little modification.

The results of the anthelmintic project have justified Dr. Ransom's judgment in inaugurating it. The method of critical testing has enabled us to use training-camp methods in determining the values of the anthelmintic weapons for use in the warfare on worms, has added new weapons, and has taught us more precise strategy and tactics; even the failures in our experimental attacks have shown us what not to do and thereby effected widespread savings in the broad field of practice. The facts ascertained have had immediate application in veterinary medicine and have in some instances been transferred successfully to the field of human medicine. As the originator of this project and as collaborator in planning it, Dr. Ransom deserves much credit for the benefits which have followed from it.

It is hardly overstating the case to say that when Dr. Ransom inaugurated the anthelmintic project he was opening up a new era in anthelmintic medication. For centuries anthelmintics by the score had been used on the basis of an uncritical empiricism. For a half century there had been an epoch of critical clinical consideration of anthelmintics, especially of those intended to remove hookworms from man, and there was a concomitant refinement of laboratory procedure in judging the

effects of anthelmintics. But critical testing opened a third phase of development with the application of the modern experimental method to anthelmintic medication and not only enabled us to obtain accurate information as to our drugs, but also to begin the correlation of the chemical and physical properties with the anthelmintic efficacy and safety, and to lay down certain broad principles in regard to these correlations and in regard to anthelmintic medication in general.

This paper represents an attempt to formulate certain broad principles which appear to be true and of value in the present state of our knowledge. In a previous paper by Hall in 1918 something of the same sort was attempted. That paper was written after two or three years of critical testing, and most of the critical testing which has been done up to the present time was done after that paper was written. It is now in order to recast the conclusions in that paper.

FACTORS IN ANTHELMINTIC MEDICATION

The essential factors in anthelmintic medication have been stated alliteratively by Hall in 1925 as the six P's: 1. Practitioner (physician or veterinarian). 2. Patient. 3. Parasite. 4. Parasiticide (anthelmintic). 5. Purgative. 6. Prophylaxis. The issue is joined when a practitioner confronts a supposedly parasitized patient. The outcome depends on the intelligent correlation of the six factors involved. None of these factors should be slighted, and in considering the tentative principles of anthelmintic medication they are grouped under these factors to emphasize the importance of such grouping.

PRINCIPLES OF ANTHELMINTIC MEDICATION

1. *Practitioner.*—The practitioner must be a person of adequate training, experience and judgment if anthelmintic medication is to be successful. He must know all the other factors. An injudicious selection of an anthelmintic may cause serious results or make the treatment unsuccessful; a failure to recognize a contra-indication for treatment may be fatal. While the importance of the personal equation seems self-evident, it is actually one that is often overlooked. One occasionally finds a writer complaining of a lack of efficacy or safety in a drug which others find effective and safe. The difference in their results evidently may follow from the obviously different factor, the individual practitioner, but it is a rare thing to find a writer suggesting that the fault may be his. The existence of a practitioner is justified by his exercise of good independent individual judgment since it is impossible for the specialist to cover in writing, as in a paper of this sort, all possible considerations.

In this connection it should be said that training in parasitology is much neglected in American medical and veterinary colleges, and that

the practitioner today is handicapped by this lack of training. This situation may be remedied in time; in the meanwhile the cautious acquirement of experience and the exercise of good judgment will serve here as elsewhere: "We learn by doing." Before using anthelmintics the practitioner should acquaint himself with the few that are of known value, learn their indications and contraindications, assure himself that the indications for treatment are present and the contraindications absent in his patient before he administers treatment, and then make sure that he obtains prompt purgation after treatment; this is in the interest of "safety first." A knowledge of the parasite and its habits, and of the dosage of the drug, will then be an aid to efficiency.

2. *Patient.*—In deciding on the drug and the size of the dose, the practitioner must carefully consider the patient—age, size, sex, food and other habits, and general condition—especially as regards the presence of certain pathological conditions discussed under the heading of *Parasiticide.*

The period of fasting before treatment may be stated in general terms, but if special conditions indicate the advisability of altering this period one way or another, it should be altered accordingly. In general, human patients can be given a light meal in the evening and treated the next morning 3 or 4 hours before the morning meal; nothing is gained, as a rule, by a longer fast, there is a decided loss in many cases in that the digestive tract is in an abnormal and usually sensitive condition as a result of unusual fasting, and there is likely to be greater weakness and more disposition to headache on the part of the patient. Dogs and cats also should be fasted only overnight. Swine require more prolonged fasting—at least 24 hours—to make an anthelmintic effective. Sheep and other ruminants require only an overnight fast in most cases, the prolonged fasting of sheep in connection with the South African copper sulphate and sodium arsenite powder being exceptional; it is out of the question and unnecessary to clear the rumen by fasting in any event. Horses require prolonged fasting, 36 hours, in connection with anthelmintics to destroy worms in the large intestine, but 12 to 24 hours is apparently sufficient in treating for stomach worms, bots, and ascarids.

The nature of the food appears to be important. Alcohol is contraindicated in connection with anthelmintics in general, and acute or chronic alcoholism is a contraindication for anthelmintic medication, especially with carbon tetrachloride. Bozzolo reported good results from the use of wine in connection with thymol, but it is possible that the alcoholic solution of the thymol in the stomach, with the subsequent precipitation of the thymol in a finely divided state as the alcohol was diluted or absorbed, might lead to increased anthelmintic efficacy without, however, lessening the danger from the alcohol. Hall in 1920 has shown experimentally the inadvisability of using fluid extracts of anthel-

mintic drugs. Carbohydrates are apparently indicated with such drugs as are most likely to cause some injury to the liver, as chloroform, carbon tetrachloride, and tetrachlorethylene. Fats, oils (with the exception of castor oil), cream and related substances are contraindicated. Whether they increase the total absorption or the rapidity of absorption, or cause localized absorption, or act in some entirely different way is not sufficiently known; such oils as olive oil tend to remain in the stomach and in connection with a depressant and constipating drug, such as chenopodium, there may be a serious resultant damage to the stomach. Proteid foods occupy an intermediate position between the carbohydrates and the fats; they are not harmful and may be desirable, at least with certain drugs. Antidiabetic diet has been recommended in connection with treatments for human pinworm infestation.

3. *Parasite.*—A knowledge of the parasite, especially of its habits, including its location and life history, is essential to sound procedure in anthelmintic medication. If a patient is subject to constant reinfection with a parasite having a life history which includes the wandering of the larvae through the body tissues outside of the digestive tract for days, weeks or months, it may happen that an anthelmintic treatment which removes all the worms from the lumen of the digestive tract will be followed by recurrent infestation as these larvae return to the digestive tract, even though the patient is removed from the sources of infection at the time of treatment. To prevent this would require removal of the patient from all sources of infection for an adequate period before treatment. What might be regarded as a successful treatment for ascarids might nevertheless leave ascarid eggs continuing to appear in the feces as a result of the existence of a female ascarid in the gall duct and out of reach of the drug. The location of the whipworm in the cecum is such that it is difficult to reach it by the common methods of treatment, even though experience indicates that this worm is relatively susceptible to comparatively weak anthelmintics; it is possible that relatively feeble anthelmintics in large doses or repeated small doses may be used successfully to reach and remove this worm. It is unnecessary to enlarge on the necessity for a knowledge of parasites on the part of the practitioner, as it seems sufficiently clear that a lack of knowledge as to enemy strength, habits, and disposition of forces must be a handicap to any commander directing an attack on that enemy.

4. *Parasiticide* (Poison!).—It is well to keep in mind that all anthelmintics are poisons, intended to poison the worms and administered in such doses as will accomplish this with a minimum of risk to the patient. In general they should not be used on the assumption that a patient is infested or even on clinical evidence to that effect, at least in private practice; it is too simple a matter to make a laboratory diagnosis and proceed with certainty. In field work where one is dealing

with thousands of persons with a high incidence of infection and with the necessity of conserving funds for treatment of the sick rather than laboratory examinations to eliminate a small percentage of uninfected individuals, mass treatment on the basis of probabilities becomes justified, at least in many cases.

In choosing an anthelmintic, one must keep in mind that these drugs are rather selective in their action. Santonin is effective against ascarids, but can be given over long periods of time without affecting hookworms or tapeworms. Chenopodium is apparently more effective against the hookworm *Ancylostoma duodenale* than is carbon tetrachloride, but carbon tetrachloride is more effective against the hookworms *Necator americanus* and *Ancylostoma caninum* than is chenopodium. Chenopodium is much more effective against *Ascaris lumbricoides* than is carbon tetrachloride, but carbon tetrachloride is almost as effective as chenopodium against the dog ascarids. In spite of the fact that chenopodium is so widely effective against ascarids in general and so superior in this respect to carbon tetrachloride, chenopodium is apparently inferior to carbon tetrachloride in removing ascarids from horses. Male fern destroys the common liver fluke, *Fasciola hepatica,* but not the lancet fluke, *Dicrocoelium dendriticum.* Tartar emetic or emetine will kill blood flukes but not *Filaria bancrofti.* These findings should warn us against too great generalities as to the value of these drugs whenever any one factor, such as the worm or host, is changed in any problem. When we know how anthelmintics affect worms, a thing concerning which we know practically nothing, we *may* be able to predict results in problems with a new factor—or we may not.

The older books state that an anthelmintic is a relatively insoluble drug intended to poison the worm and that purgatives should be given after the drug has had time to act in order to sweep it out of the digestive tract before it can be absorbed. This is perhaps closer to the description of an ideal anthelmintic than to a statement of known fact. So far as we are aware, the known anthelmintics are actually absorbed in the digestive tract to an unpleasantly large extent. Seidell in 1915 found that one-half to two-thirds of the thymol administered was destroyed or temporarily fixed in the body. Of the even more insoluble carbon tetrachloride, Wells in 1925 finds that practically all of small doses is absorbed. By solubility is meant here water-solubility. In spite of these findings, there is some likelihood that there is a correlation between the efficacy and safety of an anthelmintic and its water solubility. Hall and Shillinger in 1925 have pointed out the increasing efficacy against hookworms and the increasing safety of the patient in the series $CHCl_3$, CCl_4 and C_2Cl_4, and Hall and Cram in 1925 have shown the entire inefficacy and apparently entire safety of the theoretically

valuable, but entirely insoluble, compound C_2Cl_6, and have discussed the apparent relation of solubility and anthelmintic efficacy. It is quite probable that there is an optimum solubility of anthelmintics, a point at which they display maximum efficacy in destroying worms with a maximum safety consistent with that efficacy.

We are just beginning to obtain some data which may make it possible to definitely correlate anthelmintic efficacy with chemical composition. Caius and Mhaskar in 1923, after an extensive series of investigations of the drugs used for the removal of human hookworms, found the four most effective drugs to be for the most part rather unrelated substances—chenopodium, carbon tetrachloride, thymol, and betanaphthol. They regarded the efficacy in each particular case as correlated with the chemical composition as follows: That of chenopodium with the dioxide character of its effective constituent, ascaridol; that of carbon tetrachloride with its halogen content; that of thymol and betanaphthol with their free phenolic hydroxyl group. In the Zoological Division we have taken one group of halogen compounds, the chlorinated hydrocarbons, and found an apparent correlation between the anthelmintic efficacy and the chlorine content in such substances as $C_2H_4Cl_2$, $CHCl_3$, CCl_4, and C_2Cl_4. This correlation, as already noted, appears to be modified by the factor of water solubility, since the theoretically valuable C_2Cl_6 proved of no value, apparently because of its practically entire insolubility. Similar experiments with other halogen compounds are indicated, as well as those with compounds containing free phenolic hydroxyl groups and with dioxides.

The distinction between vermicide and vermifuge appears to be entirely academic and of little or no practical value. In the first place it is of no importance whether a worm is passed alive or dead, uninjured or sick and poisoned; a worm removed is a worm destroyed. At present we do not know how anthelmintics affect worms. They may cause muscular incoordination, as santonin apparently does in ascarids, but we do not know why santonin does not cause this in hookworms or tapeworms if it causes it in ascarids. They may dissolve fatty structures, as might be the case with carbon tetrachloride which is highly destructive to hookworms, but this is pure theory and affords no explanation as to why carbon tetrachloride should not affect dog tapeworms in the same manner. They may depress the nervous system of the worm and cause a relaxation of the hold or induce a degree of narcosis, but until we know more about the subject this is pure speculation. If the anthelmintic is purgative it may bring the worms out promptly, but if it is not, a purgative will remove them promptly and peristalsis will remove them reasonably soon in any case. In some cases a time factor should be considered, but as a rule drugs do not need much time to act in destroying worms. In many cases the purgative may be given

with the drug; in some cases a delay may be indicated owing to a possible need for time for the anthelmintic to act or because of an interaction between the purgative and the anthelmintic or for some other unknown reason; this matter should be given further consideration. The matter of anthelmintic efficacy should always be weighed in with the patient's safety, and prompt purgation is protective.

The contraindications for treatment depend on the patient and the drug. It is essential that the practitioner know the status of the patient and the effect of the drug on the host as well as on the worm. The general contraindications for anthelmintic medication, with a resultant need for omitting treatment or diminishing the therapeutic dose, are as follows: Extreme youth or old age, febrile or debilitating conditions, gastroenteritis, gross helminthiasis, alcoholism, high fatty diet, and such conditions as gastric stasis or pronounced constipation. Special contraindications depend on special effects of the anthelmintic on the patient and some of these are as follows:

Chenopodium is decidedly irritating, depressant, and constipating, and the special contraindications for this drug include gastroenteritis, pronounced weakness, gastric stasis, and constipation. Carbon tetrachloride has a rather constant effect on the liver in the production of acute yellow necrosis, and is contraindicated in cases of icterus or other hepatic derangements. Betanaphthol is said to cause destruction of red blood cells and is contraindicated in malaria and similar conditions. Chenopodium, thymol, and betanaphthol appear to be unsafe during pregnancy, but carbon tetrachloride appears to be quite safe in pregnancy and also in cases of kala azar and some pyrexias. A special contraindication for carbon tetrachloride is gross ascariasis, particularly with young and feeble patients, as this drug appears to cause a clumping of the ascarids with resultant intestinal obstruction fatal to a patient with an atonic intestine incapable of eliminating these masses; there is the further possibility that the drug dissolves certain constituents from these worms which may cause a toxic condition following its absorption by such patients. In ascariasis accompanied by gastroenteritis santonin is the drug of choice as it is not irritant.

This is by no means an exhaustive consideration of these drugs, but merely indicates something of what the practitioner must know about his drugs and his patient before administering treatment. The writer's limited experience with anthelmintics for the destruction of worms outside of the digestive tract has led to no special conclusions of interest here. The factors in this field differ, in the absence of the action of digestive fluids, and the matter of absorption by the blood, from those in anthelmintic treatment for worms in the alimentary canal, and the subject of anthelmintics begins to border on the field of chemotherapy for destruction of haematozoon parasites.

5. *Purgative* (Protection).—As noted above, prompt purgation is protective. Whether this is because of its elimination of the unabsorbed anthelmintic, which does not appear to be the general case, or because it distributes the anthelmintic along the digestive tract and thus prevents localized absorption and local injury, or whether it slows absorption and thus eases off the shock on the patient, is not definitely known, but clinical and experimental evidence all points to the value of prompt purgation. The purgative should be given at the earliest possible moment consistent with efficacy, or even sooner if safety requires it. Many anthelmintics, such as areca nut, arecoline hydrobromide, and kamala are purgative. Many combinations of anthelmintics and purgatives, such as chenopodium and castor oil, carbon tetrachloride and magnesium sulphate, and santonin and calomel, are effective for practical purposes. Whenever possible it is advisable to use the combinations, even though a diminution of efficacy necessitates repeated treatment; the idea of safety, especially in treating human beings, must be kept uppermost. We have shown that dogs will survive lethal doses of chenopodium or male fern when given with large doses of castor oil. In this connection it should be said that small doses of purgatives are decidedly contra-indicated; always give plenty, especially with such constipating drugs as chenopodium. We sometimes see reports of deaths following the use of anthelmintics in which purgation was not obtained for 24 to 30 hours. There is usually a failure on the part of the practitioner in such cases. If early purgation is not obtained by the routine procedure, extraordinary measures are indicated. One must resort to purgation by duodenal tube if purgatives are vomited; use enemas, abdominal massage or any other measures known to medical science to cause evacuation of the bowels. Constipated patients should be given a preliminary purgative the evening before treatment.

In connection with the subject of purgation it may be said that it appears to be common practice to suppose that all worms removed will pass in 24 hours after treatment, and results are sometimes judged on this basis. Actually worms may pass for days, the time depending on the worm species, the drug, and the anatomy and condition of the host. In dogs the majority of worms come away in 24 hours, and in the case of tapeworms of the genus *Tænia,* all such worms come away in this period in our experience, although this might not always be the case. We found that dog ascarids came away as follows: The first 24 hours, 82.7%; the second, 7.7%; the third, 4.3%; the fourth, 3.1%; the fifth, 1.5%; the sixth, 0%; the seventh, 0.5%. Hookworms came away as follows: The first 24 hours, 74.1%; the second, 15.7%; the third, 7.4%; the fourth, 2.8%. Whipworms came away as follows: The first 24 hours, 57.6%; the second, 15.2%; the third, 18.2%; the fourth,

10%. *Dipylidium* came away as follows: The first 24 hours, 91%; the second, 7.4%; the third, 0%; the fourth, 1.6%.

6. *Prophylaxis.*—The practitioner has not completed his task nor fulfilled his duty to his client until he has informed him as to the probable source of his trouble and the means for preventing a recurrence. He must know the life histories of the parasites involved—that ascariasis involves coprophagy and a lack of sanitation or personal hygiene somewhere; that hookworm infestation probably means skin exposure to infective larvae with concomitant lack of sanitation along the line; that trichinosis implies the eating of improperly cooked or inadequately processed pork or pork material; that infestation with certain other worms (*Dipylidium,* spirurids, and acanthocephalids) involves the ingestion of such small intermediate hosts as insects; and that filariasis is indicative of attack by infective mosquitoes.

It is not only necessary to tell this to a patient but it is necessary also to keep such information before the public as much as possible, if we are to do our duty along the lines of preventive medicine. But at this point we leave anthelmintic medication and enter another field.

A NEW PARASITIC NEMATODE FROM THE STOMACH OF AN UNKNOWN MEMBER OF THE CERVIDAE

Benjamin Schwartz
Associate Zoologist, U. S. Bureau of Animal Industry

It is appropriate that a number of the Journal of Parasitology dedicated to the late Dr. B. H. Ransom should contain a paper on the genus Ostertagia. This genus was proposed by Ransom in 1907 in one of the early attempts to break up the unwieldly genus Strongylus s. l. and to put in order the economically important trichostrongyles of ruminants.

The nematode described in this paper was forwarded to the writer by Professor E. Houdemer of the Ecole Vétérinaire at Hanoi (Tonkin), Indo-China, with the information that it was collected from the fourth stomach of a deer. In view of the fact that more than one species of deer is known to occur in that region no host determination can be given. Dr. H. H. T. Jackson, of the Biological Survey of the United States Department of Agriculture, suggested that it is not improbable that the host might be a species of Cervus.

The nematode, for which the name *Ostertagia houdemeri* is proposed, is dedicated to Professor E. Houdemer in recognition of his contributions to our knowledge of the parasitic fauna of Indo-China.

Ostertagia houdemeri, NEW SPECIES

Diagnosis.—Ostertagia: characters of the genus.

Male from 5.2 to 5.7 mm. long by about 100μ in the region of the middle of the body. The diameter of the head (Fig. 5) is about 17μ. The esophagus is from 554 to 571 μ long, club-shaped, its maximum diameter in the posterior portion being from 42 to 50μ. The nerve ring and excretory pore are located in approximately the same region, the latter being from 210 to 218μ from the anterior extremity. The bursa (Fig. 2) is 310μ wide with the lobes spread out, the diameter of the body immediately in front of the bursa being from 109 to 117μ. The prebursal papillae are located about 40μ anterior to the bursa. The ventro-ventral and latero-ventral rays have approximately the same thickness, the terminal portion of the latter being more rounded than that of the former, which tapers gradually. The externolateral and posterolateral rays have approximately the same thickness, the latter extending close to the margin of the bursa. The tips of these rays are fairly close. The distance between the tips of the mediolateral and posterolateral rays is greater than that between the posterolateral and the externodorsal rays. The dorsal ray has a short stem about 20μ long

or slightly longer and divides into two branches each of which is approximately 30μ long, dividing near its termination into two branches. The accessory bursa is supported by two slender rays. The spicules (Fig. 3) are about 176μ long with their posterior ends retracted and about 183μ with the posterior ends extended. The distance between the inner borders of the spicules near the anterior ends is 42μ. The distance from the posterior end of the retracted spicule to the posterior margin of the bursa is about 200μ.

Female 4.9 to 6 mm. long by 92 to 114μ wide in the region of the vulva. The head is from 19 to 21μ wide. The esophagus is from 487 to 537μ long by 50 to 55μ in maximum width. The width of the body at the level of the base of the oesophagus is 84μ. The nerve ring and excretory pore are approximately in the same region, the latter being from 160 to 202μ from the anterior extremity. The diameter of the body at the level of the excretory pore is 67μ. The vulva (Fig. 1) is transversely elongated, covered by a small cuticular flap, and is located at a distance of 1.9 to 2.1 mm. from the posterior extremity. The combined lengths of the muscular portions of the ovejectors, including the sphincters, is 176μ. The tail (Fig. 4) is slender and tapers gradually, its length being approximately 185μ. The cuticle in the tail region presents very marked striations which begin some distance anterior to the anus and extend some distance posterior to it. The eggs in the uterus are from 71 to 84μ long by 42μ wide.

Host.—Deer (possibly a species of Cervus).

Location.—Stomach.

Locality.—Tonkin, Indo-China.

Type Specimen.—Helminthological Collection U. S. National Museum No. 26,547; paratypes U. S. National Museum No. 26,548.

DISCUSSION

As already noted, the genus Ostertagia was proposed by Ransom (1907) who designated *O. ostertagi* (= *Strongylus ostertagi* Stiles 1892) as the type species, assigned *Strongylus circumcincta* Stadelmann 1894, to this genus, and proposed three new species from the United States, namely, *O. trifurcata* from the fourth stomach of sheep and goats, and *O. marshalli* and *O. occidentalis* from the fourth stomach of sheep. In 1909 Railliet and Henry added another species to the genus, namely, *O. mentulata* from the fourth stomach of the Arabian camel (*Camelus dromedarius*). These writers also published a brief description of *O. brigantiaca* Blanchard 1909, from the duodenum of the chamois (*Rupicapra rupicapra*).

Since the publication of Ransom's monograph on nematodes from the alimentary tract of ruminants in which the seven aforementioned species

of Ostertagia are described, the following additional species have been proposed as belonging to this genus: *O. trifida* Cuillé, Marotel and Panisset 1911 from sheep; *O. tricuspis* Marotel 1910, from sheep in France; *O. bullosa* Ransom and Hall 1912, from sheep in the United States; *O. rubida* from swine (=*Strongylus rubidus* Hassall and Stiles 1892), placed in this genus by Travassos in 1920; *O. callis* (Travassos 1914) from *Didelphys aurita,* South America; *O. ransomi* Travassos 1921, and *O. delicata* Travassos 1921, from *Cabassus unicinctus* in South America; *O. asymmetrica* Ware 1925, from *Cervus dama* in England; and *O. bisonis* Chapin 1925, from *Bison bison* in North America.

The description of *O. trifida* is not available to the present writer and the description of *O. tricuspis* is not accompanied by figures and is very brief, important specific characters not being mentioned. *O. ransomi* and *O. delicata* are also described very briefly, important specific characters being omitted, and the descriptions being unaccompanied by figures. Hall (1921) proposed the genus Hyostrongylus for *Strongylus rubidus* Hassall and Stiles 1892 (=*O. rubida* of Travassos). The absence of the accessory bursa in this species is not considered by Travassos a character of sufficient importance to warrant its exclusion from the genus Ostertagia, in which genus the accessory bursa may be greatly reduced as noted by Travassos in *O. callis.* However, the accessory bursa is the primary diagnostic character of the genus, and the lack of it in connection with the presence of branches on the dorsal ray anterior to its bifurcation has led to the adoption of the genus Hyostrongylus for the swine trichostrongyle.

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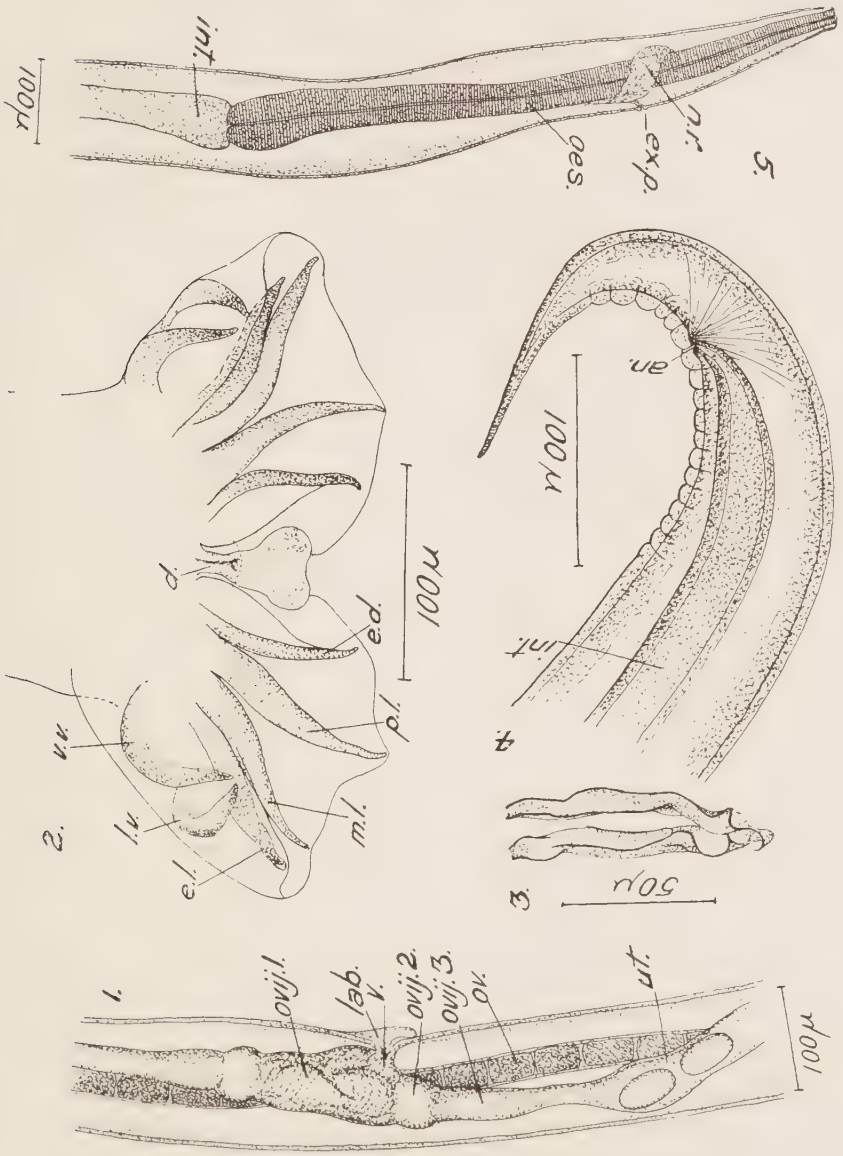


PLATE I

EXPLANATION OF PLATE

Ostertagia houdemeri, new species.

Ostertagia houdemeri. Fig. 1.—Region of vulva. Fig. 2.—Male bursa Fig. 3.—Spicules. Fig. 4.—Posterior end of female. Fig. 5.—Anterior portion of body. an., anus; d., dorsal ray; e.d., externo-dorsal ray; e.l., externo-lateral ray; ex.p., excretory pore; int., intestine; lab., vaginal flap; l.v., latero-ventral ray; m.l., medio-lateral ray; n.r., nerve ring; ovij., ovejectors; oes, oesophagus; p.l., postero-lateral ray; ut., uterus; v., vagina; v.v., ventro-ventral ray.

SOUTHWELLIA RANSOMI NEW SPECIES

EDWARD A. CHAPIN
Assistant Zoologist, U. S. Bureau of Animal Industry*

In view of the late Dr. B. H. Ransom's authoritative work on the cestodes of North American birds, it seems fitting that at least a small contribution to the knowledge of this field should be dedicated to his memory.

HISTORICAL REVIEW

The genus Southwellia Moghe, 1925, was established as a monobasic genus to include a species of tapeworm described as *Monopylidium gallinarum* by Southwell in 1921, which was collected from a domestic fowl at Berhampore, Bengal, India. Moghe, and later Meggitt, recognized the necessity of separating this species from the balance of the genus *Monopylidium* because of the unilaterality of the genital pores. Each of these authors has given a diagnosis of the genus based on the facts stated in the original specific description of the parasite and hence both diagnoses fail to describe certain important portions of its anatomy. In all characters of generic rank mentioned the species described below as new agrees so perfectly with *S. gallinarum* (Southwell) that the writer feels justified in adding to the generic diagnosis.

Six generic names have been proposed for the group of species to which the above mentioned form belongs. Of these, one (Parachoanotaenia Luehe, 1910) falls immediately into synonymy for it is antedated by Icterotaenia Railliet and Henry, 1909, both names being based upon the same type, to wit: *Choanataenia galbulae* (Zeder, 1803).

The oldest of the five names remaining is Choanotaenia Railliet, 1896, with *Choanotaenia infundibulum* (Bloch, 1779) as its type. The salient characters of this genus are: (1) Irregularly alternating genital pores; (2) genital canals passing between the dorsal and ventral excretory canals, and (3) the presence of a persistent uterus which may be subdivided into numerous communicating chambers. The second of the names, in point of time, is Monopylidium Fuhrmann, 1899, type species *Monopylidium musculosum* (Fuhrmann, 1896). This genus agrees with Choanotaenia Railliet in having irregularly alternate genital pores and in the relation of the genital ducts to the excretory ducts, but is separated from it by the structure of the gravid uterus. Here the uterus breaks down into separate noncommunicating chambers or egg capsules, each capsule containing one or more eggs. It is the contention of Clerc

* Now Associate Entomologist, Taxonomic Investigations, U. S. Bureau of Entomology.

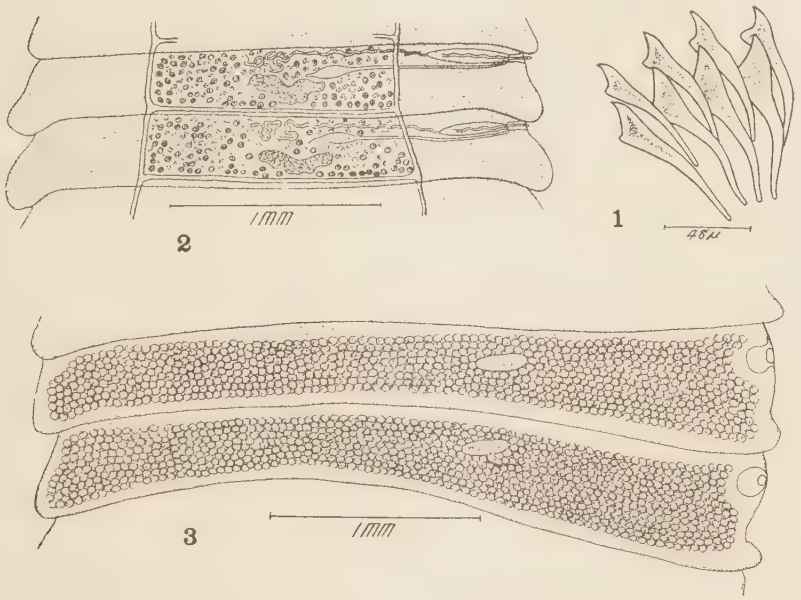
(1903) and Fuhrmann (1907, 1908) that *Choanotaenia infundibulum* (Bloch) does not have a persistent uterus and that the two genera are synonymous, although they would remove *Ch. infundibulum* (Bloch) to Monopylidium Fuhrm. and maintain Choanotaenia as a good genus but with a new type species. This procedure is, of course, contrary to the International Code and was recognized as such by Railliet and Henry (1909) who suppressed Monopylidium Fuhrm. in favor of Choanotaenia Raill. and proposed the new name Icterotaenia Raill. and Henry, 1909 for the balance of the old genus Choanotaenia. Ransom (1909) made a careful study of the type species of Choanotaenia and came to the conclusion that Clerc and Fuhrmann were in error in their interpretation of the condition of the uterus, and that, on the contrary, the species does have a persistent uterus and is distinct from Monopylidium. The writer has restudied the sections prepared by Ransom and believes that the specimen identified as *Ch. infundibulum* (Bloch) and sectioned by him does have a persistent uterus and further that there is no reason to doubt the correctness of the determination. With the acceptance of this fact, Icterotaenia Railliet and Henry, 1909 drops into the synonymy of Choanotaenia Raill., 1896 and Monopylidium Fuhrm., 1899 remains as originally characterized.

The next name to be considered is Southwellia Moghe, 1925, based on *Monopylidium gallinarum* Southwell, 1921. As stated above, this genus is at once separated from Monopylidium Fuhrm. and Choanotaenia Raill. by the character of the genital pores which are strictly unilateral. An additional character of importance, the position of the genital canals as dorsal to both of the excretory canals, has been determined by a study of the material described below. There remains for examination the subgenus Macracanthus Moghe, 1925. This is a segregate of *Monopylidium* to include three species which have rostellar hooks of large size. In other characters it agrees with Monopylidium Fuhrm. Under no circumstances can the name Macracanthus Moghe be sustained since it is preoccupied by Macracanthus Chaudoir, 1846, a genus of insects. No type species was designated by Moghe; and until a type is designated and it is shown that there are additional reasons for a separation of the species of Monopylidium into two groups, it seems best to merely drop the name.

SOUTHWELLIA MOGHE, 1925

Diagnosis.—Dipylidiinae; strobila of numerous segments all of which are broader than long, rostellum muscular and armed with two rows of large (80-100μ) hooks, suckers unarmed, neck absent, genital primordia appearing early, genital pores strictly unilateral, genital ducts passing dorsally of both of the longitudinal excretory canals, genital atrium present, cirrus pouch long and muscular containing a somewhat coiled

cirrus, cirrus armed with minute spines, vas deferens much coiled, lying in the anterior portion of the segment, vagina opening posterior to the opening of the cirrus pouch, vagina long, leading into a large receptaculum seminis, ovary median, near the posterior border of the segment, vitellaria diffuse, testes many in each segment, distributed generally throughout the portion of the segment bounded by the lateral excretory canals, gravid uterus extending beyond excretory canals to the edges of the segment, breaking down into numerous heavily walled cavities each of which contains many embryos.



Southwellia ransomi n. sp. Fig. 1.—Rostellar hooks. Fig. 2.—Mature segments. Fig. 3.—Gravid segments.

Type Species.—Monopylidium gallinarum Southwell, 1921 equals *Southwellia gallinarum* (Southwell).

A second species of this genus was collected by the writer from the intestine of a fledgling robin, *Turdus migratorius* Linn., found dead at Washington, D. C., June 9, 1926, by Dr. Albert Hassall. The examination revealed the presence of twelve tapeworms belonging to a single species, numerous immature nematodes belonging to the genus Porrocaecum and a few nematodes belonging to the genus Capillaria. The parasites were not the immediate cause of death. This was due to strangulation, the bird having eaten a quantity of heavy cotton string which completely filled the stomach and esophagus.

The species of tapeworm is here described as new under the name of *Southwellia ransomi* N. SP.

Specific Diagnosis.—Southwellia; rostellar hooks of two sizes and arranged in two rows, each consisting of 30 hooks. The hooks of the inner row are the larger, measuring 96μ in length; those of the outer row measure 80μ. The rostellum is very muscular; it is 480μ in length by 350μ in diameter. The suckers are not prominent but are directed anteriorly. Just back of the scolex the width of the strobile is about 920μ. Segmentation commences almost immediately and the genital primordia can be detected in stained mounts at a distance of 2 mm. behind the scolex. Well formed testes appear in the 25th to 32nd segment following and about 60 segments beyond this point the segments may be pronounced mature. The first gravid segment is about the 75th following the appearance of maturity. The mature segment is 2.56 mm. wide and 0.32 mm. long. The genital atrium is situated at the anterior corner of the left margin. It is about 50μ deep and 20μ in diameter. The cirrus pouch is 400μ in length by 64μ in diameter and extends inward almost to the ventral excretory canal. The vas deferens runs along the anterior margin of the segment following a tortuous course to the median line of the segment where, directly anterior to the ovary, it makes a complex system of turns and spirals. The vagina lies posterior to the vas deferens and consists of a simple, straight tube, ending in the receptaculum seminis at the left and slightly anterior to the ovary. The receptaculum is 272μ by 60μ. There are many testes in the mature segment, each of which is about 24μ in diameter. The ovary is crescentic in shape, transverse, lies near the posterior border of the segment and measures 288μ by 80μ. The ventral excretory canal is very much larger in diameter than the dorsal and in some parts of the worm there appear additional longitudinal canals which are not continuous from segment to segment.

The gravid segment is 3.52 mm. broad by 0.40 mm. long. The receptaculum seminis persists, other organs of the mature segment have disintegrated. The egg capsules vary greatly in size, averaging over 100μ in diameter. The hexacanth embryo measures about 48μ in diameter, the outer envelope about 80μ. The embryonic hooks measure 18μ in length.

The entire worm may be as long as 80 mm.

Host.—*Turdus migratorius* Linn.

Location.—Small intestine.

Locality.—Washington, D. C.

Collector.—E. A. Chapin, June 9, 1926.

Type.—An entire specimen stained with carmine, U. S. Nat. Mus., Helm. Coll. No. 27,171. Paratypes: serial sections (transverse) and alcoholic material, No. 27,172.

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REDESCRIPTION OF *TÆNIA KRABBEI* MONIEZ

ELOISE B. CRAM
Zoological Division, U. S. Bureau of Animal Industry

INTRODUCTION

Tænia krabbei is one of the great number of parasites which came under the personal consideration of Dr. Ransom, with his wide interests in parasitology and his extreme thoroughness in dealing with every problem which he undertook. In connection with his study (1913) of *Cysticercus ovis* in mutton, Dr. Ransom gave a very complete comparison of the sheep-measle tapeworm with other species, and through his studies, made in this connection, of Moniez' description and illustrations of the larval and adult forms of *Tænia krabbei,* he realized that the latter was very incompletely described. There were at that time in the collection of the Zoological Division specimens of cysticerci found by Dr. D. S. Neuman in the muscles of reindeer in Alaska. Dr. Ransom made a careful study of these for incorporation in his paper and in order to compare the Alaskan reindeer cysticercus with *Tænia krabbei* more definitely than was possible from the inadequate description of the latter, he requested and secured from Professor R. Blanchard cotype specimens of Moniez' material, both larval and adult forms. He was thus enabled to add the sizes of the hooks of *T. krabbei,* an important detail not formerly known, and to enlarge the description of the cysticercus. He concluded from his studies that the Alaskan reindeer cysticercus was probably of the same species.

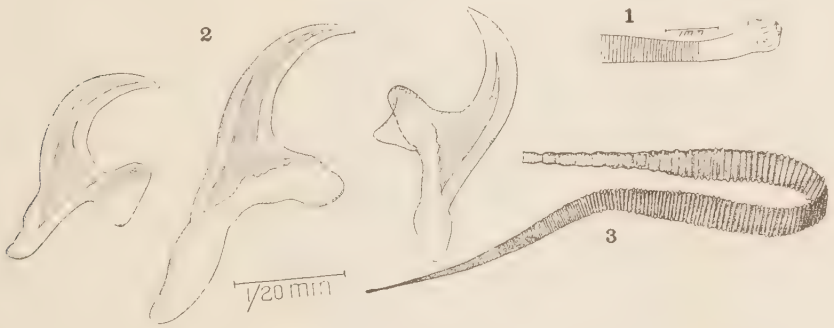
Dr. Ransom intended at a later date to redescribe the adult form of *T. krabbei,* on the basis of the cotype material in his possession. Hall (1919) in his Adult Tænioid Cestodes of Dogs and Cats and of Related Carnivores in North America described only the external characteristics of *Tænia krabbei,* adding that "Dr. Ransom . . . will later publish a study supplying a description of the internal anatomy." This, however, was one of the many projects which was not to be fulfilled as planned, the untimely death of Dr. Ransom writing finis to the career of one of the most prolific workers in the field of parasitology and thus cancelling the hopes and prospects of important contributions coming from him to the yet unsolved problems of the subject.

The writer has therefore chosen to make a study of the cotype material of *Tænia krabbei* and while realizing that the results of her efforts will be greatly inferior to those which the subject would have received had the original plans been brought to fruition and Dr. Ransom's meticulous care and breadth of experience been applied to the subject,

she has been particularly happy in being able to carry on one step farther the work started by him whose loss we mourn.

Tænia krabbei MONIEZ, 1879

Specific Diagnosis.—Hall (1919) made a detailed study of the head (Fig. 1) of the same cotype material used by the present writer; his description is as follows: "The head is very small, about 500μ in diameter, presenting a generally spherical appearance when viewed from the side and a square outline when viewed en face. The rostellum bears a double crown of 26 to 34 hooks. The large hooks (Fig. 2) are 148 to 170μ long. The blade is of moderate curvature; the handle is strikingly polymorphic, either straight, curved in a simple curve, with the convexity of the curve dorsal or ventral, or wavy, may have its sides approximately parallel or may taper or thicken toward the distal



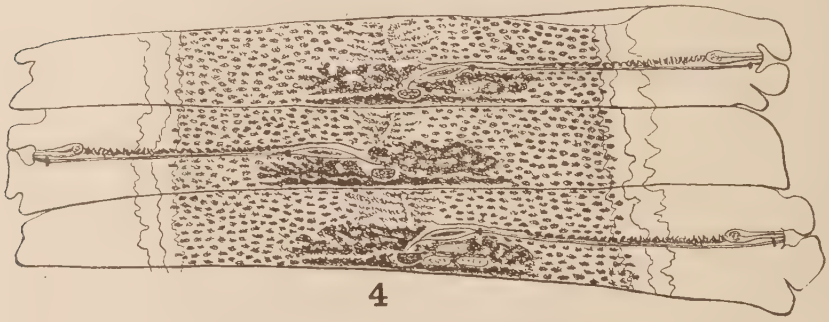
Tænia krabbei. Fig. 1.—Head. Original. Fig. 2.—Hooks. After Hall, 1919. Fig. 3.—Entire strobila; reduced. After Moniez, 1880.

extremity, may be slightly or deeply notched on the dorsal border or not at all notched; the guard is generally cordiform to oval. The small hooks are 85 to 120μ long. They have a blade of strong curvature; the handle is tapering, straight or somewhat curved, but in either case with a tendency to curve dorsally at the tip; the guard is cordiform to oval in lateral view and has usually a slight median groove. The suckers are inconspicuous. The neck is narrow and distinct and appears to be about 1 mm. long in cotype specimens."

The following description by the present writer provides the much needed detailed study of the morphology: Strobila (Fig. 3) about 20 cm. long; maximum width about 9 mm. With the exception of 3 or 4 terminal gravid segments, the segments are all much wider than long, mature segments isolated for study at a distance of 28 mm. from the head measuring 600μ long and 5.8 mm. wide. The terminal gravid segments measure about 4 mm. long and 4.5 mm. wide. The genital papillae, irregularly alternate with from 2 to 5 following consecutively

on the same side, are very large, occupying almost the entire lateral margin in the mature segments. The genital atrium in such a mature segment (Fig. 4) is about 280μ deep, with the genital openings at the base. The ventral longitudinal excretory canals are large and are spirally twisted; they are situated about 800μ from the lateral margin; the dorsal longitudinal canals are much smaller and are situated slightly farther in from the margin, lying within the field occupied by the testes. The calcareous corpuscles are numerous, especially in the lateral fields; they vary considerably in size (10 to 16μ in diameter), shape, and degree of staining.

The most striking thing in the appearance of mature segments, when sectioned and stained, is the compact appearance of the organs, all of them being very much compressed and elongated in the transverse axis of the worm. The central group of genitalia is not exactly median



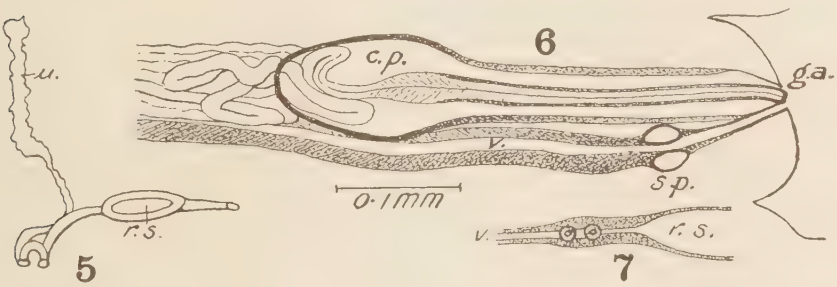
Tænia-krabbei. Fig. 4.—Mature segments. Original.

but is slightly shifted to the pore side so that as the position of the genital pore changes from one side to the other, the genital organs shift from one side to the other of the median line (Fig. 4).

Male Genitalia.—The testes are comparatively large and very numerous, appearing to fill every available space, there being no clear fields devoid of genitalia within the limits bounded laterally by the excretory canals, except for a very narrow strip just internal to these canals. The testes number about 260, there being about 115 between the central group of genitalia and the poral margin, and about 145 between this genital group and the aporal margin. The testes are of irregular outline, roughly oval, with the long axis corresponding to the transverse axis of the segment; they closely approach the ovaries laterally and anteriorly, lie close to the vagina and vas deferens on each side and are interspersed in among the outpocketings of the uterus in the median field. A few extend laterally beyond the dorsal excretory canals, lying ventral to the latter. The vas deferens is apparently without a vesicula

seminalis and its origin is obscure, but it apparently arises as fine branches a short distance from the uterus, on the pore side, and extends in an unusually straight course toward the pore, lying in close juxtaposition to the vagina the entire way, there being practically no visible space between them even in sections. The vas deferens is often pigmented and has a sinuous course out to the ventral longitudinal excretory canals; between this canal and the cirrus it is highly convoluted, the convolutions lying in a space lined by a thin membrane that is thrown into folds. The cirrus pouch (Fig. 6) is thick-walled and about 400μ long; it extends about half the distance from the base of the genital atrium to the ventral longitudinal excretory canal. The cirrus very rarely protrudes into the genital atrium in the available material; in one gravid segment this protrusion was noted.

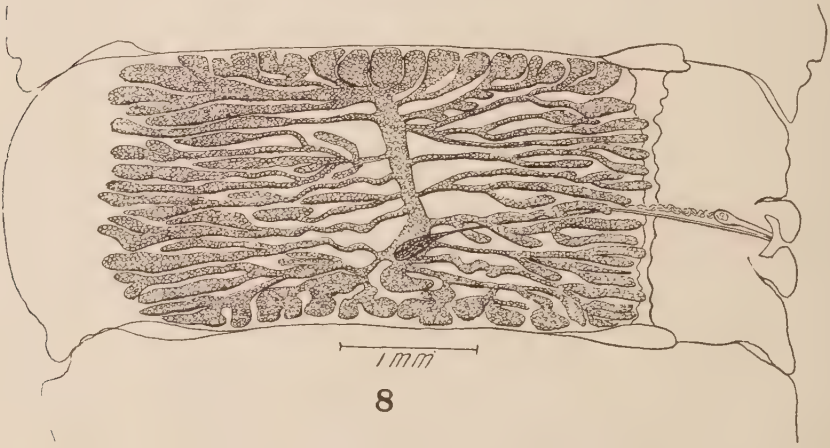
Female Genitalia.—The ovaries are of loose structure, distinctly elongated in the transverse axis of the worm, the one on the aporal



Tænia krabbei. Fig. 5.—Female genitalia in immature segment. Original. Fig. 6.—Cirrus pouch and outer end of vagina. Original. Fig. 7.—Sphincter at inner end of vagina. Original. c.p., cirrus pouch; g.a., genital atrium; r.s., receptaculum seminis; sp., sphincter; u., uterus; v., vagina.

side being the larger, not only extending farther anteriorly than the other ovary but spreading out into the median field anterior to the shell gland; the ovary of the poral side is compressed in the space between the vagina and the vitellarium, the receptaculum seminis and the vagina lying directly along its anterior margin. The vitellarium of very dense structure is situated at the extreme posterior margin of the segment in close juxtaposition to the ovaries and extends laterally as far as the ovaries extend and anteriorly in the median interovarian field where the so-called shell gland lies apparently embedded in it. The shell gland is large and instead of being globular, is compressed to a spindle shape, measuring about 200μ in its long axis, which corresponds to the transverse axis of the segment. The outpocketings of the uterus appear in the mature segments, this precocious development further complicating the study of an already compactly filled segment. Such pockets, filled with young ova, appear not only in the anterior median

part of the segment, but are found in many instances directly anterior to the shell gland, invading the latter so as to give it a crescentic shape, and also occur in the ovary of the pore side (Fig. 4). The vagina, which is not pigmented, curves slightly posteriorly around the cirrus pouch and then proceeds in an unusually straight course as far as the ovary where it curves slightly anteriorly and lies directly along the margin of the ovary. There is a well-developed sphincter vaginae (Figs. 5 and 6) near the pore; at the inner end of the vagina, near the receptaculum seminis, the tube apparently forms a dorsal loop (Figs. 4 and 7) so that one sees two cross sections of it and this loop and the short portion connecting it with the receptaculum seminis are surrounded by a wall considerably thickened in comparison with the subsequent and antecedent parts and apparently of muscular structure, which may pre-



Tænia krabbei. Fig. 8.—Gravid uterus; original.

sumably act as a second sphincter vaginae. The first or outer sphincter is apparent in early immature segments; the second is of later development, appearing only in fully mature segments. The receptaculum seminis, 200 to 216μ long, is strongly developed; it lies slightly diagonally anterior to the median half of the ovary of the poral side. In immature segments (Fig. 5) the median stem of the uterus corresponds approximately to the longitudinal axis of the worm but in both mature (Fig. 4) and gravid (Fig. 8) segments it slants obliquely from the aporal toward the poral side as it proceeds from the anterior margin to the middle of the segment. In the gravid segment the uterine branches and pockets of the aporal side are more strongly developed than those of the poral side, this asymmetrical development corresponding to that of the genitalia in the mature segment. There are only 9 or 10 branches arising from the median stem of the uterus; they are comparatively straight and very slender, in many cases containing only a single row of eggs.

The anterior and posterior margins of the segment are almost entirely filled with large, more or less globular pockets, 14 to 18 in number, densely packed with eggs. The primary uterine branches give off secondary branches which terminate in pockets; in the lateral fields of the segment these pockets, 20 to 24 in number on each side, are greatly elongated transversely. Egg elliptical, 33 to 36μ by 27 to 30μ.

Hosts.—Primary: *Canis familiaris.* Secondary: *Rangifer tarandus* (*Tarandus rangifer*).

Location.—In the small intestine of primary host; in voluntary muscle of secondary host.

Locality.—Iceland, Alaska.

Larval Stage.—The cysticercus, known as *Cysticercus tarandi,* is small and is considerably elongated in form, measuring about 3 mm. long by 1.8 mm. wide. The surface of the bladder is mammillated. The orifice of invagination is commonly at one end instead of at the side; the invaginated head and neck, commonly curved spirally, are large, both actually and relatively in comparison with the size of the bladder, there being very little space for fluid within the vesicle.

Cotype Specimens.—Nos. 17,351 and 17,352 U. S. N. M. (Bureau of Animal Industry Helminthological Collections).

COMPARISON WITH OTHER SPECIES

As regards the size of the large hooks of the head, *Tænia krabbei* (hooks 148 to 170μ) falls with *T. ovis* (hooks 156 to 188μ) and *T. hydatigena* (hooks 170 to 220μ) in an intermediate group of the tænioid tapeworms of carnivores between that group on the one hand which has smaller hooks (not exceeding 145μ), and which includes *T. balaniceps, T. brauni,* and *T. brachysoma,* and that group on the other hand which has larger hooks (not less than 225μ) and which includes *T. pisiformis, T. macrocystis, T. tæniaeformis* and *T. laticollis.*

The genital papillae also appear to be more strongly developed in *T. krabbei* than in any related forms, as even the papillae of *T. ovis* and *T. macrocystis,* which are large, are relatively inferior in this respect to *T. krabbei.*

With regard to the internal anatomy, the extreme compactness of the segment and the compression of practically all the genital organs so that their long axes correspond to the transverse axis of the worm appears to place *T. krabbei* in a class by itself among dog tapeworms and the known carnivore tapeworms. The size and position of the receptaculum seminis of this species are striking; in *T. pisiformis* and *T. hydatigena,* in which the receptaculum may be well-developed, it lies a considerable distance from the ovary and parallels the longitudinal axis of the segment, and in *T. ovis,* although the position of the recep-

taculum directly along the anterior margin of the ovary may be similar to that of *T. krabbei,* it is much less strongly developed than in the latter. The presence of sphincters at either end of the vagina is a very interesting characteristic of *T. krabbei.* Hall (1919) was apparently the first one to describe and figure a sphincter vaginae in a tænioid tapeworm of a carnivore, *T. tæniaeformis* showing this structure well-developed at the outer end of the vagina. Similar observations have been made, however, in the case of tapeworms other than those in the Tæniidae. According to Braun (1897) the formation of a sphincter is probably a modification of the muscular sac which is found to enclose the vagina in some tapeworms, the muscle having been limited to a very localized point. The list of tapeworms given by the above author as possessing such sphincters includes *Tænia fillicollis* Rud. (=*Ichthyotænia fillicollis*) and *T.* (*Ichthyotænia*) *fossata* (Riggenbach) (=*Proteocephalus fossata*), which are proteocephalids; *Moniezia planissima* Stiles and Hassall and *M. expansa* (Rud.), which are anaplocephalids; *T. capitellata* Rud. (= *Hymenolepis capitellata*), a hymenolepid; *Calliobothrium coronatum* (Rud.), an onchobothriid; *Anthobothrium auriculatum* (Rud.) and *Echeneibothrium myliobatis aquilae* Dies., which are phyllobothriids; and *Diplobothrium simile* Ben., which Southwell (1925) places in Cyclophyllidea, family uncertain. This last tapeworm, according to Loennberg (1891) has two sphincters vaginae, the outer lying slightly interior to the vaginal opening at the origin of a widened portion, the inner near the proximal end of this part which by means of these sphincters can function as a receptaculum. *Echeneibothrium myliobatis aquilae,* mentioned above, also has two sphincters, according to Zschokke (1889), one at each end of a widened, receptaculum-like portion of the vagina.

Tænia krabbei is seen by the above comparison to be fairly closely related to *T. ovis,* but in addition to the differences cited above, there are these others: The grouping of the genital organs in the mature segment, in *T. ovis* being medianly located, in *T. krabbei* being shifted toward the poral side; the lateral extent of the vitellarium, which in *T. ovis* is considerably less than, and in *T. krabbei* equal to, that of the ovaries; the cirrus pouch, the inner end of which in *T. ovis* touches the ventral excretory canal, and in *T. krabbei* is at a point only about half way from the pore to the canal; and even more striking, the character of the gravid uterus, which in *T. ovis* is equally developed on poral and aporal sides and has slender, elongated pockets at anterior and posterior ends and a straight median stem from which arise 20 to 25 lateral branches, whereas in *T. krabbei* the uterus is more strongly developed on the aporal side and has large more or less globular pockets at the anterior and posterior ends and a median stem sharply bent at its

posterior third, slanting anteriorly and posteriorly from this point toward the aporal side of the segment. There can therefore be no doubt that *T. krabbei* is a specifically distinct species.

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SUMMARY OF RESULTS OF FIELD TRIALS BY THE U. S. BUREAU OF ANIMAL INDUSTRY ON OX-WARBLE CONTROL

MARION IMES
Veterinarian, Zoological Division, U. S. Bureau of Animal Industry.

In 1915 Dr. B. H. Ransom, chief of the Zoological Division of the U. S. Bureau of Animal Industry instructed the writer to arrange for some field experiments on ox-warble control. Dr. Ransom was very much interested in all phases of the subject and especially in finding some practical method of control or eradication to reduce or prevent the heavy losses in leather caused by warble punctures. He made many valuable suggestions during the progress of the work which was begun in 1916 and continued as time and available funds would permit.

The field inspection and tick eradication divisions of the bureau cooperated in the work through their field organizations. Many of the field experiments were conducted by bureau field inspectors in accordance with plans and instructions and under the supervision of the writer. The active workers were Drs. F. L. Schneider, W. A. Savage, H. E. Kemper, and V. A. Dennis in New Mexico; F. E. Murray and E. R. McClure in Utah; W. E. Howe and Rudolph Snyder in Colorado; and Marion Imes in Kansas.

Bureau inspectors supervising the dipping of cattle in the southern part of the United States to eradicate ticks (*Margaropus annulatus*) observed and reported that systematic dipping in arsenical dip apparently reduced and in some instances seemed to eradicate the ox-warble fly. Since experiments including undipped controls could not be conducted in areas where tick-eradication work was in progress without seriously interfering with such eradication work, arrangements were made to conduct field trials in New Mexico, Colorado, and Utah.

EXPERIMENTAL WORK

Savage selected 30 range cattle near Tucumcari, New Mexico and marked each animal for identification. They were divided into 6 lots of 5 head each. Each lot was dipped in regulation low-strength arsenical dip. Lot 1 was dipped 6 times beginning May 17 and ending October 31, 1916. Lot 2 was dipped 5 times beginning May 17 and ending Sept. 30. Lot 3 dipped 3 times, first dip May 17 and last dip July 31. Lots 4 and 5 were dipped twice; the first dipping of lot 4 was on May 17 and the last dipping June 16; lot 5 first dipping June 16, last dipping July 31.

The treated cattle grazed with 50 untreated cattle and mingled with them at all times during the experiment. The herd was examined from time to time and the first warble was found in the treated cattle Oct. 31, 1916. From that date to Jan. 20, 1917, warbles continued to appear in the usual locations on the treated and untreated cattle. The warbles began to emerge on January 11, and at the last inspection January 23 only a few remained on the cattle.

The dipped cattle and the controls were all infested. Lots 1 to 3 inclusive showed a less number of warbles than lots 4 to 6. The controls and lots 4 to 6 were about equally infested. Since the fly appears in the vicinity of Tucumcari as early as February 20 it is evident that

TABLE 1.—*Cattle Dipped in Arsenical Dip for Ox Warbles, Buttes, Colo., 1916. Six Head in Each Lot.*

Lot No.	Dates Dipped 1916	Days Between Dips	No. of Dips	Total No. of Warbles	Average No. of Warbles	Remarks
1	March 22	..	10	40	13⅓	3 head not found; only 3 examined
	April 5	14				
	April 19	14				
	May 4	15				
	May 17	13				
	May 31	14				
	June 30	30				
	July 31	31				
	Aug. 31	31				
	Sept. 30	30				
2	April 5	..	9	57	14¼	2 head not found; only 4 examined
	April 19	14				
	May 4	15				
	May 17	13				
	May 31	14				
	June 30	30				
	July 31	31				
	Aug. 31	31				
	Sept. 30	30				
3	April 5	..	7	100	20	1 head not found; only 5 examined
	May 4	29				
	May 31	27				
	June 30	30				
	July 31	31				
	Aug. 31	31				
	Sept. 30	30				
4	April 5	..	2	121	20⅙	
	May 4	29				
5	Control lot	..	..	127	25⅜	1 head not found; only 5 examined

the dipping was begun too late and another experiment was started February 13, 1917.

Two lots of 5 cattle each were dipped in arsenical dip 7 times at varying intervals beginning February 13 and ending June 2, 1917. Lot 1 was dipped in the usual manner but lot 2 was treated by dipping only the legs and ventral surface of the body. Three additional lots of 5 cattle each were treated. Lots 3 and 4 were dipped in the usual manner, the former was given 4 dippings beginning April 5 and ending June 2, and the latter was dipped 3 times beginning April 21 and ending

June 2. Lot 5 received 3 dippings of the legs and ventral surfaces only, beginning April 21, and ending June 2.

The 5 lots of treated cattle mingled with 10 untreated cattle during the experiment. November 30, 1917 the warbles in each lot of treated cattle were counted. Lot 1 showed 40 warbles; lot 2, 39; lot 3, 54; lot 4, 73; and lot 5, 76. The controls were infested to about the same extent as lots 4 and 5.

Howe and Snyder dipped 4 lots of cattle of 6 head each in arsenical dip near Buttes, Colorado during 1916 and the data are arranged in Table 1.

Murray and McClure sprayed 20 cattle with arsenical dip near Salt Lake City, Utah, during the spring and summer of 1916, and the results are shown in Table 2.

TABLE 2.—*Cattle Sprayed with Arsenical Dip for Ox Warbles, Salt Lake City, Utah, 1916. Five Head in Each Lot.*

Lot No.	Date of First Spray 1916	Interval Between Sprayings (Days)	Date of Last Spray 1916	No. of Sprays	Total No. of Warbles	First Warbles Found 1916	Remarks
1	May 5	14	October 5	12	24	December 18	
2	July 14	14	October 6	7	49	December 15	1 died Dec. 7, 1916; no warbles
3	July 14	28	October 6	3	29	December 22	
4	July 14	28	August 11	2	8	December 29	
5	Control lot.....				12	December 15	1 died Sept. 3, 1916

Arsenical dip apparently is not an effective remedy for controlling or eradicating ox-warble flies. Field observations indicate that repeated dipping in any of the known cattle dips limits or reduces infestation, but probably not to a sufficient extent to be of economic value because cattle owners are reluctant to incur the expense of repeated handling and dipping.

WADING-VAT EXPERIMENTS

The wading-vat experiments published by Imes and Schneider in 1921 were continued in New Mexico and Kansas.

Imes selected 4 yearling heifers and confined them in a barnyard near Kansas City. Beginning March 1 and continuing until Aug. 31, 1921, two of the heifers were treated daily in a wading vat. The vat was charged with water to a depth of about 10 inches and sufficient fuel oil was added to form a layer about 2 inches deep. The heifers were kept under observation until the following March; one of the treated animals showed 8 warbles and the other one was free from infestation. One of the controls showed 40 warbles and the other one was free.

Another lot of 4 barnyard calves was selected and from March 1 to Sept. 1, 1922, two of them were daily passed through a wading vat

charged to a depth of about 12 inches with 2 per cent pine-tar-emulsion One of the treated calves showed 30 warbles and the other one was free. One of the controls was free from infestation and the other one showed 22 warbles.

Five cows from a dairy herd of 12 head were daily passed through a wading vat charged with 2 per cent pine-tar-emulsion to a depth of 12 inches. Treatment was begun April 19 and ended August 31, 1922. The following winter the herd was examined and the 5 treated animals showed a total of 33 warbles. The 7 controls showed a total of 33 warbles or a less number per animal than the treated lot.

Another dairy herd of 24 cows near Kansas City was divided into two equal lots and one lot was treated daily from April 24 to Sept. 1, 1922, in a wading vat charged with a 2 per cent solution of coal-tar-creosote dip to a depth of from 10 to 12 inches. The following winter no warbles could be found in the treated cattle and the 12 controls showed light infestation or a total of 43 warbles. On account of inclement weather and delay in getting the vat ready the work in the two last mentioned tests was probably started too late.

Kemper selected 24 range cattle and placed them in a pasture near Carrizozo, New Mexico. Since wild range cattle usually refuse to enter a wading tank a controlled overflow from the watering troughs was conducted into a natural depression in the ground thus forming a shallow pond. Gravel was hauled and thrown into the pond and soon became tramped into the soil forming a bottom that held water satisfactorily. The watering was enclosed by a fence having an opening at the pond. The cattle could get to the water troughs only by passing through the pond which they did readily.

March 24, 1922, automobile cylinder oil that had been used, or what is commonly known as crank-case drainings, was added to the water in the pond to form a layer about one inch deep. In passing through the pond the cattle's legs became coated with oil. More oil was added from time to time and the experiment continued until July 4 when it became necessary to move the herd on account of shortage of grass.

The treated cattle were examined the following winter and 10 head showed no warbles; 12 head showed very light infestation or an average of about 4 warbles per animal. The remaining two which were known to be fence breakers and to have watered at many different places, showed 15 and 18 warbles respectively. A herd of 13 cattle grazing in the adjoining pasture was used as controls. One of the controls showed no warbles and the 12 others showed infestation varying from 1 to 28 warbles, with an average of about 14 per animal. This test, however, was begun rather late, as most of the heel-fly activity would be over on March 24.

Two wading vats were installed in Union County, New Mexico by cattle owners in 1922. The vats were charged with water and used automobile cylinder oil. Dennis reports that the cattle owners were well pleased with the results since they are of the opinion that the treatment prevented "gadding" or stampeding of their cattle by the warble fly.

CONCLUSIONS

1. Arsenical dip, used as in the experiments, is not a satisfactory remedy to control or eradicate ox-warble flies.

2. Repeated dipping in any of the known cattle dips limits or reduces infestation but does not eradicate the fly.

3. Treatment of cattle during the fly season in wading vats charged with a 2 per cent solution of coal-tar-creosote dip or processed crude petroleum or similar oils prevents gross infestation but does not effect complete eradication.

4. The wading-vat method of applying fly repellants or insecticides to the legs of cattle is practical and economical for use on farms.

5. Wading vats can successfully be adapted to range use when watering places can be fenced.

6. Processed crude petroleum or similar oils and 2 per cent solution of coal-tar-creosote dip are the most effective of the medicaments used in the field trials.

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COMPARATIVE VALUE OF SODIUM HYDROXIDE, COPPER SULPHATE, AND FERMENTATION IN DISINFECTING HUMAN EXCRETA CONTAINING EGGS OF HOOKWORMS (*NECATOR AMERICANUS*) AND OF ASCARIS (*ASCARIS LUMBRICOIDES*) *

C. W. Stiles

Professor of Zoology, U. S. Public Health Service

Upon my transfer from the U. S. Bureau of Animal Industry to the U. S. Public Health Service, it became necessary to organize *de novo* personnel and equipment in the new Division of Zoology. The first assistants chosen were four young men, recently from college, namely, Garrison, Murray, Ransom, and Stevenson. Later, when requested to recommend to the Bureau of Animal Industry a man to serve as my successor, the choice fell upon Ransom who seemed to present exceptional promise for progressive conservatism in research. Ransom served with me in the Hygienic Laboratory from Sept. 15, 1902, to June 1, 1903, and we remained in constant and cordial professional relations up to the time of his death.

Aside from his professional ability and industry, certain personal characteristics were outstanding in his general make-up; he was a quiet, unassuming man, very deliberate in expressing an opinion; evenly poised and very good-natured in his disposition; serious minded in many respects, he possessed a keen sense of wit which would express itself at unexpected moments in a distinctly refined dry humor. All in all, Doctor Ransom was an exceptional man, with whose services as assistant I was content to part only because his transfer to the Bureau of Animal Industry gave him unusual and independent opportunities for advancement.

In the disinfection of human excreta, emphasis has usually been placed upon the danger of bacteria, especially of typhoid fever and of Asiatic cholera. This fact results from the point that the geographic distribution of the more serious intestinal zooparasites is more restricted than that of the more dangerous bacteria, and hence the latter have seemed to present the broader, the more general, and more important problem.

It is, however, clear that because of the importance of zooparasitic infections in warmer climates, and especially in rural localities, methods of disinfection developed on basis of conditions which obtain in colder climates and in urban localities are not to be assumed, *a priori,* to be universally applicable. It seems also clear, *a priori,* that a method developed to disinfect a typhoid stool might not be applicable to excreta containing the eggs of Ascaris, hookworms, Clonorchis, Opisthorchis, Paragonimus, Tænia, Diphyllobothrium, etc., or the mature larvae of

* This paper is a condensed abstract of a report made to the Surgeon General on experiments conducted at Wilmington, N. C., in 1917.

hookworms and Strongyloides, or the cysts of Endamoeba or Giardia s. Lamblia, as these stages of the parasites in question are protected by more or less resistant covers.

The present known methods of killing the free stages of the animal parasites cannot be called entirely satisfactory, for they involve greater expense and labor than will ordinarily be expended.

It seems doubtful whether proper disposal of human excreta will ever become satisfactorily general or universal so long as the impelling motive is simply one of public health. If, however, the disposal can be one which will combine an economic factor with the public health aspect, and if the excreta can be turned to some practical use, as fertilizer, the chances for more general excreta-disposal are distinctly increased.

The experiments reported here involved the use of (*a*) fermentation, (*b*) pine-oil disinfectant (coefficient of 4), (*c*) a representative proprietary coal-tar disinfectant (coefficient of 12), (*d*) sulphuric acid, (*e*) calcium hypochlorite, (*f*) copper sulphate, and (*g*) sodium hydroxide (caustic soda). The work was conducted at the U. S. Marine Hospital, Wilmington, N. C., in the summer of 1917.

METHOD OF WORK

The problem of studying the effects of a disinfectant upon the various stages (cysts, eggs, larvae) of animal parasites is radically different from that present in bacteriological studies. The method of disinfecting a stool and then planting culture to grow colonies is excluded; the method of disinfecting and then trying to develop the germ to a later stage is often not entirely satisfactory since so many complicating factors are involved and therefore negative results might be very misleading. Apparently a more feasible method of procedure is to subject the material to the action of a given disinfectant and then to examine slide after slide in order to find the organisms, and to pass judgment on each separate egg or cyst as to whether it is "alive," "doubtful," or "dead." This method is, of course, excessively tedious and time-consuming and the reliability of the conclusion depends upon the number of eggs or larvae counted and the personal judgment of the observer. The point can also be raised that it is an unusually severe test and even ultra-severe, since ova and cysts may become nonviable before they show changes distinguishable under the microscope; this point shows, however, that the method is a *safe* one upon which to base conclusions involving life and death of human beings as affected by the results.

In the present work (1) excreta were taken from can privies; (2) a measured quantity of this material (feces plus urine) was placed in mason jars, and disinfectant added to give a definite percentage of disinfectant as compared with the total mass; (3) samples were taken

from the jars and (4) centrifuged (in order to concentrate the eggs); (5) the centrifuged specimens were examined in smears microscopically; and (6) judgment was passed on the condition of the eggs, namely: as to whether they were "alive," "doubtful," or "dead."

In judging an egg as "dead," the standard was adopted that the protoplasm should show distinct signs of change, such, for instance, as disintegration. The appearances varied somewhat for the different methods of disinfection. In *sodium hydroxide,* for instance, the disintegration and clearing were particularly marked.

It was impossible to draw as sharp a line between the "alive" and "doubtful" as between "doubtful" and "dead," and of the eggs classified as "doubtful" some were probably "alive" and some "dead"; although it is likely that relatively few of them were so unchanged as to permit later development, had optimum opportunity presented. As each experiment advanced, the eggs in the jar naturally became fewer in number, owing to the complete disintegration of many ova.

Parallel experiments of three kinds were used, namely:

A.—At summer room temperature:
(1) Without a layer of kerosene on top of excreta.
(2) With a layer of about ½ inch of kerosene; this was added as fly repellant and in order to see whether its presence had any material effect in the death rate of the eggs.

B.—In ice box:
(3) Without a kerosene layer on top.

An attempt was made to count the same number of eggs in each experiment, but this soon proved to be impracticable because the degree of infection in different stools varied to such an extent.

Very early in the experiments the fact developed that the best results were being obtained with *sodium hydroxide* and with *copper sulphate;* compared with these, the results obtained with the other methods of disinfection were so far inferior (as regards time) that the findings are (except for fermentation) chiefly of academic interest, and the other four disinfectants (*calcium hypochlorite, pine oil,* a commercial preparation, and *sulphuric acid,* 1 per cent solutions) are not worthy of serious consideration in disinfecting human excreta containing eggs of Necator and Ascaris.

SODIUM HYDROXIDE (CAUSTIC SODA)

Sodium hydroxide is a common reagent, used for years by zoologists in "clearing up" nematodes, arachnoids, insects, etc., for microscopic study. The fact that the solution acts so promptly in softening hard tissue such as the chitin of insects and the egg shells of various parasites, led to experiments to find out whether it would kill the fresh hookworm eggs in excreta. Certain commercial toilets use a caustic as disinfectant

and liquifacient. (See also observations by Oliver [1910], Yoshida [1918], and Bruns [1904.]) The present manuscript claims nothing in the sense of advancing a new principle, and its value is therefore restricted to the data obtained and the resulting possible extension of this application of caustic soda to a wider field of use based upon a more detailed knowledge of the findings under the microscope.

The tests at Wilmington (1917) were made with excreta treated with a sufficient amount of sodium hydroxide to make 5, 2, 1, 0.5, 0.2, 0.125 and 0.1 per cent disinfectant in the total mass.

Yoshida (1918 and 1920) reports that eggs of *Ascaris lumbricoides* can develop in 1 per cent caustic soda.

Comparison of 5, 2, 1 and 0.5 Per Cent Sodium Hydroxide.—The following comparative tabular summary (Table 1) of egg counts shows that all four of these solutions are evidently or probably safe disinfectants against hookworm eggs, the factors of period of action (time) and capacity of storage increasing as the strength of the solution decreases.

The error, if present, will be on the side of safety, if the premises be accepted that as long as recognizably live hookworm eggs are present, the disinfectant is *"not safe,"* but that if no live egg is found and if a relatively few ova are classified as doubtful, the disinfectant may be "nearly safe." If no egg is classified as alive or as doubtful, the conclusion as to safety must depend either upon the number of dead eggs found or upon the point whether the eggs have been destroyed and have disappeared. From Table 1 the following conclusions appear justified so far as hookworm eggs are concerned:

Conclusion.—In 14 days (2 weeks) action, a 1 per cent solution of *sodium hydroxide* is sufficient to destroy hookworm eggs in excreta (taken from can privies) in summer; in colder weather the period of action should be increased; in winter it is wise to increase the period to 42 days (6 weeks).

If the time limit is decreased, the strength of the solution should be increased. If a 2 per cent solution is used, the summer disinfection can be reduced apparently with comparative safety to 9 days, but a 14-day period is, of course, safer. If a 5 per cent solution is used, it is apparently safe to reduce the summer period to 6 days.

If a 0.5 per cent solution is used, it is necessary to increase the period of disinfection; summer disinfection should probably last at least 4 weeks, winter disinfection probably at least 8 weeks.

To insure results the caustic must come into contact with the ova, hence in mass-disinfection agitation of the mixture (excreta and disinfectant) is absolutely essential.

Odor.—In addition to the experiments in jars, with 400 to 8,000 cc. total mass, one test was made in the open, under a tree, with 160 liters,

TABLE 1.—*Summary of Experiments with Sodium Hydroxide, Comparing Results Obtained by 5, 2, 1 and 0.5 Per Cent*

Days' Action		Percentage of Disinfectant 5	2	1	0.5	Necator Eggs Alive	Doubtful	Dead	Ascaris Eggs Alive	Doubtful	Dead	Temperature Summer	Icebox	Safety, Chiefly in Respect to Hookworm Infection
1st week	1	5				2	158	1,200	7	37	60	+	—	Period not safe
	1		2			..	..	182	..	..	..	+	—	do.
	1			1		61	30	20	..	..	1	+		do.
	1			1		3	11	75	..	9	30		+	do.
	2	5				..	37	638	1	10	64	+	—	Period nearly safe
	2		2			..	14	85	..	13	14	+	—	do.
	2			1		19	17	1,085	2	12	62	+	—	Period not safe
	2			1		9	12	21	1	5	11	—	+	do.
	3	5				..	1	522	..	9	69	+	—	Period apparently safe
	3		2			1	6	160	..	8	22	+	—	Period nearly safe
	3			1		2	3	1,031	1	9	40	+	—	do.
	4	5				..	1	79	..	3	37	+	—	Period apparently safe
	4		2			..	2	67	..	4	9	+	—	Period nearly safe
	4			1		1	35	1,727	1	15	175	+	—	Period not safe
	4			1		1	55	70	..	1	34	—	+	do.
	4				0.5	1	..	4	..	..	..	+	—	do.
	5	5				..	2	522	..	8	217	+	—	Period apparently safe
	5		2			..	..	249	1	20	4	+	—	Period nearly safe
	5			1		..	11	50	..	6	6	+	—	Period not safe
	6	5				..	..	643	..	..	411	+	—	Period evidently safe
	6			1		..	..	458	..	1	44	+	—	Period nearly safe
	6				0.5	2	6	16	..	1	1	+	—	Period not safe
	7		2			..	..	252	..	22	103	+	—	Period nearly safe
	7			1		..	1	207	..	2	7	+	—	do.
	7				0.5	2	12	21	..	..	..	+	—	Period not safe
2nd week	8		2			..	..	470	..	6	250	+	—	Period apparently safe
	8			1		..	2	577	..	13	107	+	—	Period nearly safe
	9		2			..	..	639	..	..	306	+	—	Period apparently safe
	9			1		..	3	467	..	11	83	+	—	Period nearly safe
	9				0.5	6	..	7	..	.	1	+	—	Period not safe
	10			1		..	4	1,186	2	23	207	+	—	Period nearly safe
				1		..	10	3	1	1	1	—	+	Period not safe
					0.5	..	5	12	..	..	1	+	—	do.
	11			1		..	..	1,026	..	6	143	+	—	Period apparently safe
	11				0.5	1	5	10	..	..	..	+	—	Period not safe
	12			1		..	..	1,027	..	14	132	+	—	Period apparently safe
	13			1		..	..	58	..	..	4	+	—	do.
	13				0.5	..	1	112	..	..	1	+	—	Period nearly safe
3rd week	16			1		..	..	50	..	5	6	—	+	Period not safe
	19			1		..	51	128	..	1	25	—	+	do.
	20			1		1	11	9	..	1	1	—	+	do.
	20				0.5	..	..	42	..	1	4	+	—	Period nearly safe
4th week	23			1		..	..	102	..	..	26	+	—	Period evidently safe
	25			1		..	6	50	..	1	8	—	+	Period nearly safe
	28			1		..	11	76	..	2	34	—	+	do.
5th week	29			1		..	2	62	..	..	8	—	+	do.
	31			1		..	..	514	..	6	64	+	—	Period evidently safe
	32			1		..	11	110	..	4	25	—	+	Period nearly safe
	33			1		..	6	448	..	2	78	—	+	do.
	35			1		..	5	20	..	5	7	—	+	do.
6th week	37			1		..	4	413	..	1	148	—	+	Period nearly safe
	40	5				Material almost dissolved								
8th week	53				0.5	..	..	400	..	..	8	+	—	Period apparently safe
	55			1		..	..	69	..	..	3	+	—	do.
10th week	65				0.5	..	..	97	..	..	..	+	—	Period probably safe

total mass, in a barrel. Excreta from the can privies of a cotton mill village were placed in the barrel with sufficient *sodium hydroxide,* 10 per cent solution, to give a 1 per cent disinfectant. The object of this experiment was to test the factor of offense due to odor.

When the barrel was first filled, odor was noticeable about 10 feet away. During the 10 days the experiment lasted there was very little odor, and this was rarely distinguishable more than 2 feet away except on the leeward side when it could sometimes be noticed for a distance of 10 feet.

When the barrel was emptied, by diluting the contents with water and running it off on the soil, some odor arose from the ground, but this was not more than that usually noticed when barnyard manure is spread. Exceedingly few flies were attracted to the spot and these remained only a few moments. The odor was "musty" and only slightly fecal.

The following day the soil (sand) on which the material was placed was discolored and in one portion it was covered with a dried crust. There was not the slightest odor noticeable and flies were conspicuous by their absence. No basis for complaint could possibly arise from the procedure adopted, and the single experiment was a distinct success.

COPPER SULPHATE

The point that gave rise to the thought of trying *copper sulphate* in these experiments was the fact that this substance is used by veterinarians and farmers in the treatment of sheep for verminous gastritis due to a strongyle nematode (*Haemonchus contortus*) belonging to the same superfamily as the hookworms and with an egg very similar to that of hookworms. The question naturally arose whether a substance which can be used against adult strongyles with such apparent success could not be used with equally satisfactory results against strongyloidea eggs.

The solutions used in the tests were 1 per cent and 3 per cent. Experiments were made at room temperature and in the icebox.

In addition to the mason-jar tests, one experiment was made in the open, under a tree, with 160 liters total mass, to notice the extent of the odor. The results in respect to odor were very satisfactory. There was much less offensive odor than is generally experienced from a wheelbarrow full of manure and the attraction of flies to the material was very slight. The excreta and paper were not so well disintegrated as in the corresponding *sodium hydroxide* experiment, so that the barrel could not be emptied easily through a hose, and the contents had to be dipped out. During the 12 days the experiment lasted, the barrel was screened against flies and in addition a thin film of kerosene oil covered the top of the mass of excreta.

Two difficulties developed in studying the effects of the disinfectant upon the eggs. The solution darkens the outer layer of the shell of Ascaris eggs to such an extent that in many cases it is impossible to pass safe judgment upon their viability, hence these instances cannot be considered in the statistics. In numerous other instances, the judgment reached was so uncertain that the *copper sulphate* statistics on Ascaris eggs can scarcely be taken as even approximately correct. The solution darkened very perceptibly the protoplasm of the hookworm eggs and since this darkening later changed to unmistakable signs of death, it has been interpreted as an initial sign of death. It is, however, not excluded that this interpretation may not be free from criticism. Accordingly, the data given for *copper sulphate* should be taken with reserve unless amply confirmed by independent workers. A second difficulty arose from the fact that the eggs were not infrequently surrounded by a coagulum which made it necessary to leave them entirely out of study or record.

According to Oliver (1910) *copper sulphate* is not so effective as the iron salt.

Conclusion.—There are strong indications that *copper sulphate* 1 per cent is just as good a disinfectant as *sodium hydroxide* against hookworm eggs, and possibly it may prove better, but certain elements of uncertainty indicate the wisdom of reserving judgment upon this point.

FERMENTATION EXPERIMENTS

It is common experience in laboratory experiments with hookworm eggs that the ova die more or less rapidly in fermenting excreta. In the present series of tests, 7 experiments were made at Wilmington, N. C., in order to determine the approximate time element.

Necator.—At the end of 28 days, 4 eggs in a total of 15 (count on the day in question) were classified as alive; at the end of 64 days of action, 5 eggs in a total of 101 (count on the day in question) were classified as doubtful. Accordingly, at the end of 2 months fermentation, it is not safe to assume that all of the eggs are dead. After 132 days, 299 eggs counted (on the day in question) were all dead.

Ascaris.—At the end of 51 days of fermentation, 1 egg in a total of 18 was classified as alive and 7 as doubtful; at the end of 64 days of action, 1 egg in a total of 3 was classified as doubtful; after 132 days, 244 eggs counted (on the day in question) were all dead.

Conclusion.—Fermentation will kill eggs of hookworms and of Ascaris if continued over a long period of time (a 10 weeks' period is not always sufficient in summer temperature), but the results do not compare satisfactorily (as regards time) with those obtained with *sodium hydroxide* 1 per cent. A period of 19 weeks appears to be

"safe" both for Necator and for Ascaris, and possibly further observations will show that a period shorter than 19 weeks but longer than 10 weeks will suffice in summer. Results will, of course, vary with the composition of the excreta, as from patients with a meat or a vegetable diet.

The great advantage of the use of fermentation is that the cost of a chemical disinfectant is saved. A great disadvantage of fermentation, however, is that storage capacity must be extensively increased.

The definite conclusion can be drawn, based upon general laboratory experience, that fermentation is a satisfactory method of killing eggs of Ancylostoma, Necator, and Ascaris, provided the process is continued long enough. Time is the great factor of importance.

SUMMARY

The hookworm eggs in excreta taken from can privies in New Hanover County, N. C., were killed in a 1 per cent solution of *sodium hydroxide* (caustic soda) within 14 days under summer conditions (room temperature and in the open); a 2 per cent solution killed the eggs within 9 days; a 5 per cent solution killed them within 6 days; a 0.5 per cent solution killed them within 4 weeks.

Under winter conditions (icebox experiments), the eggs live longer; apparently safe disinfection of hookworm eggs can be obtained with a 1 per cent solution in 6 weeks but with a 0.5 per cent solution in not less than 8 weeks (possibly longer).

For practical general purposes a 1 per cent solution might be recommended if only hookworm and Ascaris eggs came into consideration; if the time element is an important matter, a 2 per cent or, better still, a 3 per cent or a 5 per cent solution seems advisable under unusual conditions, as in time of war with segregation of large numbers of troops, thus with a very large increase in the mathematical probability of spread of infection, the use of a 2 per cent solution for at least 2 weeks in summer and 6 weeks in winter, would at present be clearly indicated; but in view of the results obtained for bacteria, a 3 per cent solution is distinctly preferable to one of lower strength.

Copper sulphate may perhaps eventually prove to be as safe a disinfectant for hookworms as *sodium hydroxide,* but this question is *sub judice.*

Sulpuric acid 1 per cent, *calcium hypochlorite* 1 per cent, *pine oil* disinfectant (coefficient of 4, Hygienic Laboratory formula) 1 per cent, and *fermentation* are, thus far, below *sodium hydroxide* when the element of time has to be taken into account.

Fermentation is an entirely satisfactory method of killing hookworm eggs provided it is continued a sufficient length of time (about 5 months) and with ample moisture.

Ascaris eggs, because of their more resistant shell, withstand the effect of disinfectants longer than hookworm eggs, but the periods of disinfection mentioned for hookworms reduce so greatly the danger of the spread of Ascaris that the chances of infection are enormously decreased, when compared with present conditions.

The protecting envelope of the cysts of the nonpathogenic *Endamoeba coli* and of Giardia s. Lamblia is apparently less resistant than that of the Necator eggs. In 1 per cent *sodium hydroxide* these cysts seem to die as rapidly as do the eggs of Necator, or more so.

A priori it might be expected that 1 per cent *sodium hydroxide* would kill typhoid bacilli more promptly than it does hookworm eggs; but in a case of this importance, only definite experiments should be used as premises for deduction.

A priori it is to be expected that 1 per cent *sodium hydroxide* will kill the hard-shelled eggs (Trichuris, Taenia, Diphyllobothrium, Fasciola, Fasciolopsis, Paragonimus, Opisthorchis, Clonorchis, etc.) less promptly than it kills thin-shelled eggs (Necator).

From all present indications, *so far as hookworms are concerned, sodium hydroxide* 1, 2, 3 or 5 per cent forms one of the most efficient disinfectants known for human excreta, and, further, *so far as hookworms are concerned*, it seems that excreta *properly treated* with this disinfectant can (from public-health standpoint) be safely used as fertilizer. The problem as to whether this is an economical proposition and the question of burns are not considered in this paper.

NOTES ON THE LIFE HISTORY OF *OEDEMAGENA TARANDI* L. AND *CEPHENOMYIA TROMPE* MODEER

S. Hadwen
University of Saskatchewan

INTRODUCTION

It is with kind memories of my friend Dr. B. H. Ransom that I speak of the help and encouragement which I received from him during our long friendship. It was through representations made by Ransom to Dr. Nelson, Chief of the Bureau of Biological Survey, that I visited Alaska and Lapland on behalf of the American Government. On my return to Washington from Alaska a publication entitled "Reindeer in Alaska" was written by Mr. L. J. Palmer and myself. As Ransom had been of such assistance I was naturally very anxious to acknowledge it in our paper, but owing to some regulation we were only allowed to thank Bureaux but not individuals, excepting those who were not in government employ. I am thus very glad of an opportunity of mentioning these facts, and though I was not permitted to thank Ransom at the beginning or end of the paper, there is a small foot note on page 58 which expresses a little of my gratitude to him. In the notes which follow on the life-histories of *Oedemagena tarandi* and *Cephenomyia trompe,* Ransom's name is mentioned several times, especially in connection with the immunity acquired by reindeer against warble grubs. Ransom, up to the very end, was intensely interested in this problem of immunity or resistance to parasites, and had he lived a few years longer, would have done much, I am sure, in his quiet painstaking way to get at the root of the whole question.

In concluding this introduction I must add a little about the man himself. The quality in him that I admired most was the absolute fairness in his judgment of other men's work. There was no bias in his criticisms for race or creed. He just wanted the truth. In a long visit which he made with me to Saskatchewan in 1919 we traveled over a large portion of the province and also that of Alberta, doing the roughest kind of work, conducting postmortem examinations on horses, often under the most adverse conditions, yet I never once heard Ransom complain. At the conclusion of this trip Ransom wrote an article on some of the parasites we had collected. My first intimation that he had done so was the receipt of a typewritten copy of the article itself. Ransom had put my name before his at the head of the paper! Dr. Mohler, Chief of the Bureau of Animal Industry, kindly arranged

things for me, and the order of the names was reversed. I mention this occurrence to show how generous my friend was, also for another reason. Under our names were designated the departments for which we worked, one American, the other Canadian. I may be wrong, but I believe this is the first instance where officers from the Departments of Agriculture of both countries ever published a joint article, and the credit was entirely due to Ransom.

My final word about Ransom is that America has lost a citizen and experimentor of the very first rank, and the writer a friend who can never be replaced.

SEASONAL OCCURRENCE OF OE. TARANDI

In the Norton Sound District of Alaska the season for *Oe. tarandi* extends from the latter part of June to the first days in September. Flies were taken on June 27th and as late as September 9th. The height of the season is during July and the beginning of August. In a single day (Aug. 4, 1920) over two hundred female flies were taken at a reindeer camp. Warm weather is favorable to the fly, but it can withstand far more cold and wet than the other species of warble flies with which the writer is familiar. For instance on the morning of Aug. 25, 1920 there was a sharp frost and ice covered the pools on the "tundra" but later in the day when the sun came out, the flies appeared and were attacking the reindeer with undiminished vigor. Again towards the end of August and the beginning of September, flies were seen to oviposit on cloudy days with intermittant showers. On one occasion some reindeer were confined in a muddy corral, in which there were pools of water standing. The insects after laying eggs would come to rest on the lumps of mud which rose above the surface of the water. In another instance a dying fawn was found on a hill side lying in the wet grass. Ten females were captured by hand on this animal. They were not very active, but nevertheless they were crawling about on the fawn's legs and flanks laying their eggs.

RANGE OF FLIGHT

Oe. tarandi naturally keeps close to the reindeer herds, but there are occasions on which the flies are left behind, when a herd is driven to another grazing ground late at night or at some other time when the flies are not on the wing. They seem to be capable of making long flights, however, otherwise it is impossible to explain the large numbers which are to be seen attacking the herds at one time. Flies were repeatedly taken several miles from reindeer herds, generally on reindeer trails, but also on hill tops. The Eskimos build rock cairns on the coast hills and *Oe. tarandi* commonly frequents them. Doubtless the

stones retain the sun's heat, but they also afford protection from the wind and they are dry, which may be an added attraction. Copulation may occur in such places, but was not observed. During the two summers spent in Alaska only one male fly was captured.

EGG LAYING

Oviposition occurs principally on the parts of the body which come in contact with the soil when an animal is lying down, i. e., the flanks, the legs and the brisket. On a standing animal the fly lays its eggs mostly in the regions of the stifle joint behind, and the elbow in front. Few eggs are deposited lower down on the legs. The number of eggs which may be found on a reindeer's skin is astonishing, as many as 796 having been counted on one half of a reindeer's body. The eggs are attached mostly to the fine wooley down which constitutes the under coat. The number of eggs laid by a single female numbers a little over 500. This figure is arrived at from the examination of 3 females which were taken out of their pupal cases. Egg laying is a very pressing function for the female as she lives such a short time, and flies confined in a box or vial usually oviposit before they die. Such eggs invariably failed to hatch. A more successful method of obtaining fertile eggs was to hold a fly in the fingers and to place some reindeer hair under its abdomen. The ovipositor would soon dart about among the hairs and begin to affix eggs.

HATCHING OF EGGS

It is difficult to duplicate the natural environment of the eggs on a reindeer's coat. Two batches of eggs collected by holding reindeer hair up to a fly's ovipositor hatched in 6-7 days (7 and 51 eggs). Other eggs collected from reindeer (time of oviposition unknown) hatched in five days, in one case 122 out of 400 eggs hatching. The eggs were kept in small vials with a little moist paper. When no moisture was added the eggs failed to hatch, though eggs from the same animal supplied with moisture did so. The egg vials were kept in the writer's waistcoat pocket, so they received a little body warmth during the day but not at night.

PENETRATION OF THE SKIN BY THE LARVAE

Although the actual penetration of the skin by the larvae was not observed by the author, the facts he has gathered furnish proof that they do so. He has found numerous small newly hatched larvae of about 1 mm. in length under the skin. Eggs hatch unaided off the reindeer. Skin lesions resembling those which follow the penetration of *H. lineatum* have been observed. There is a definite migration of the larvae from the legs to the back. In one reindeer 107 larvae were

found under the skin of one fore and one hind leg. Supposing that there were an equal number of eggs on the other legs the figure would approximate the average number of grubs which ordinarily are found in a reindeer's back at a later date. An examination of the exudate surrounding the larvae under the skin shows a marked eosinophilia in the older deer, which is a defense reaction of the tissues against parasites.

THE EFFECTS OF OVIPOSITION ON REINDEER

The irritation and annoyance to reindeer caused by the egg laying habits of *Oe. tarandi* can be classed under two heads—first to the herd as a whole, and secondly to the individual animals. Early in the season a few startled, kicking animals will spread fear throughout the herd, just as it happens with cattle when Hypoderma is about. Later in the year when the animals have become accustomed somewhat to fly attack, the fear is not as great. But if the flies are numerous then the whole herd begins to "mill" round and round.

Linnaeus on his voyage to Lapland describes the terrifying effect Oedemagena has on reindeer. He failed, however, to show the difference there is between the fear engendered by Oedemagena and that produced by Cephenomyia. The effect of Oedemagena on a single animal is about as follows: as soon as the fly touches the deer a severe shock goes through its body. The animal jumps or kicks and then looks around and listens for its tormentor. If it feels it again its jumping and kicking is repeated, and when struck for the third or fourth time the reindeer becomes thoroughly frightened and thinks of flight. At times a reindeer will look and search for the fly, meanwhile stamping with its feet, evidently attempting to destroy its tormentor. Reindeer do not "lose their heads" and stampede as badly as cattle when *H. bovis* is attacking them, nevertheless the constant and repeated attacks of the fly worry the animals at a time of the year when they should be resting and putting on flesh.

The unrest, the trampling, the grunting, the rapid movements, the terror which is evinced by the deer must be seen to be appreciated. Linnaeus wrote at great length on this question. In all his experience he evidently had never seen animals so harrassed and tormented by such a small insect, but as stated before it must not be forgotten that *C. trompe* also plays a most important part.

GROWTH OF LARVAE IN THE HOST

The smallest larvae found under the skin were about 1 mm. in length. Several measured 1.1 mm., a larger number 1.2-1.3 mm. and onward. The earliest record was on August 4th, but it is safe to say that larvae could be found earlier than this. The first date on which the average length of the larvae was ascertained was on September 14th (See

Fig. I) when 79 larvae were measured. No averages were made with less than 10 larvae and the highest number was 143. The principal reason for establishing the rate of growth in *Oe. tarandi* was for comparison with *C. trompe*. *Oe. tarandi* grows fairly evenly throughout the year whereas *C. trompe* takes on a sudden habit of growth in the early spring. (See paragraph on *C. trompe*.)

From measurements of larvae secured by Dr. Ransom and the writer from newly imported reindeer at Athenia, New York, it would seem that the rate of growth in both Alaska and Norway is about the same. Fifty larvae collected March 13th averaged 1.7 cm., and 50 collected March 24th averaged 2.1 cm. Alaskan larvae collected on March 24th and 27th averaged 1.5 cm. and 2.1 cm.

Immunity to Oedemagena will be discussed in another paragraph; one fact should be mentioned here, however, concerning the arrested development of larvae. In several instances small living larvae were

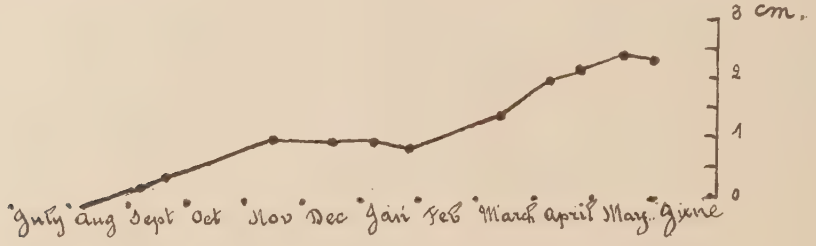

Fig. N° I Oe. tarandi

found in the backs of animals which were otherwise slightly parasitized. Six larvae taken from an adult reindeer on Jan. 11, 1921 averaged 6.6 mm. at the same date the average for normally grown larvae was 1.25 cm. In another case examined in January, two living, well grown larvae were found, and on the same skin numerous dead and flattened larvae. On the legs small living larvae may be found late in the autumn. On November 26th four live larvae measuring 0.55 mm., 0.45 mm. and 5.4 mm. in length were taken, and on the back of the same animal the average length of the larvae was 1.17 cm.

From the above it can be seen that many larvae become arrested in their development in the bodies of reindeer. A conclusion which could be drawn from this would be that certain portions of the subcutis possess the power of inhibiting the growth of the larvae without actually killing them. Probably this is because in a previous year the places chosen by these stunted larvae had been occupied by other grubs, and the tissues had developed a greater power of resistance which would not be found in other parts of the body not previously parasitized. These ideas fit in with the progressive immunity to Oedemagena which develops with the age of reindeer.

IMMUNITY

Yearling reindeer have the largest number of larvae in their backs "but when they reach three years of age it often happens that they have only a few grubs, and when adult life is reached at 5-6 years they may escape altogether." In old age the immunity apparently disappears in some cases as heavy infestations were recorded in old animals. The immunity appears to be acquired slowly and progressively as a rule but there are some exceptions, as several reindeer skins were seen in which the outline of hundreds of larvae were noticeable. The larvae were small and their death must have occurred suddenly at an early stage in their existence. Of possible significance in the arrested development of the larvae is Ransom's observation that ascarids in sheep (which is not their proper host) grow very little, but survive for a long period.

It would seem likely that reindeer fawns may inherit some degree of immunity from their dams, or else it is acquired very rapidly during the course of infection. Evidence of this was found in examining a large number of cases of dermatitis on the legs which are caused by the penetration of Oedemagena. Fawns and yearlings are the worst sufferers from this disease, which consists in large oedematous swellings on the legs followed by an exfoliation of the skin. On the exfoliated skin it was easy to find eggs, and on dissecting further into the legs numerous larvae were encountered.

The great irritation from the sores, their oedematous nature and the presence of eosinophiles indicates that the body is defending itself against the invading parasites.

THE PREVENTION OF WARBLES IN REINDEER

When reindeer are introduced into a new territory, if it is possible to move them before egg laying has started and all grubs have been removed from their backs, they should remain free from infection. On St. Lawrence Island in Alaska there is a large herd which is absolutely free from warbles. In infected territory the following method will prove of value in cutting down the percentage of infection: After most of the grubs (toward the end of June) have left the reindeer's backs, the animals should be driven as far away as possible from the point where the grubs have fallen, the idea being that when the flies emerge they will not be able to catch up with the herd and will die. In Alaska the percentage of infection is much higher than it should be on account of the methods used in handling the herds. In Lapland, owing to the nomadic habits of the Laps the reindeer herds are constantly moving and the writer has observed that the percentage of infection from Oedemagena in that country is much lower than it is in Alaska.

In Finnish Lapland dark sheds are provided for the reindeer in some districts and this too must be a wonderful means of protecting the animals from all forms of biting flies.

The late Dr. Ransom discussed this problem and many others with the writer in connection with parasitism in reindeer. It is gratifying also to record that herd owners in Alaska have benefited from his advice.

VARIATIONS IN THE COLOR OF *Oedemagena tarandi* WITH SPECIAL REFERENCE TO THE SPECIES *Oedemagena terrae-novae* KNAB

When a large series of flies had been pinned it was noticed that there were considerable variations in color.

In several cases instead of orange colored hair on the abdomen, which is typical of *Oe. tarandi,* the flies had lemon yellow hair instead. The series showed that Knab's species *Oe. terrae-novae* is nothing more than a color variant and therefore should be relegated to the list of synonyms. The writer is indebted to Dr. J. M. Aldrich for allowing him to examine Dr. Knab's types.

SUMMARY OF THE FACTS GATHERED ON THE LIFE HISTORY OF *Oedemagena tarandi*

The fly is on the wing from the end of June to the beginning of September.

The eggs are laid mainly on the fine woolly hairs of the under coat, principally on the flanks, brisket and the upper part of the legs.

Eggs may be deposited by the fly after the manner of *H. lineatum* in cattle, i. e., without necessarily alighting on the deer.

Experimentally eggs hatched in 6-7 days.

The young larvae bore through the skin and large numbers have been found crawling up the muscle sheaths towards the back. This is a definite migration.

The earliest larvae found under the skin were on Aug. 4th.

The first holes made by larvae through the skin of the back were on September 26th.

Therefore the migration of the larvae from the legs to the back must take several weeks.

The earliest record of mature larvae escaping from the back was on May 12th. On July 1st most of the larvae have left the body.

The dermatitis which follows the boring of the larvae through the skin causes severe losses among young reindeer.

The larvae grow at a regular rate throughout the year, thus differing from those of *Cephenomyia trompe.* The latter remain small all through the winter and take on a sudden habit of growth in the early spring.

The immunity to Oedemagena develops as the animals grow older and disappears again with old age.

The reason for the arrested development in the growth of numerous larvae found in reindeer suggests that certain portions of the sub-cutis possess the power of inhibiting the growth of larvae without actually killing them. The late Dr. Ransom suggested to the writer that this arrested development was on a par with his observations on ascarid larvae in sheep, the larvae never reaching normal size, owing to their being in an unsuitable host.

Rapid changes of feeding ground during the warble fly season lessen the number of grubs found the following year.

Cephenomyia trompe

"*C. trompe* has about the same seasonal activity as *Oe. tarandi* from June to September, but is never so numerous." The largest number of larvae taken from a deer's head was about 30, whereas with *Oe. tarandi* up to 1,000 larvae have been counted in a single hide.

RANGE OF FLIGHT

This must be very similar to that of *Oe. tarandi.* Numbers of flies were captured away from the reindeer herds round about the rocky cairns on the coast hills. On one occasion a number of flies were noticed circling round the tops of some alder bushes high up on a hillside; doubtless copulation occurs when they are circling round high objects.

DEPOSITION OF LARVAE

This was observed many times. The fly hovers for a few moments in front of a reindeer's nose then darts in and deposits its larvae in the nostrils.

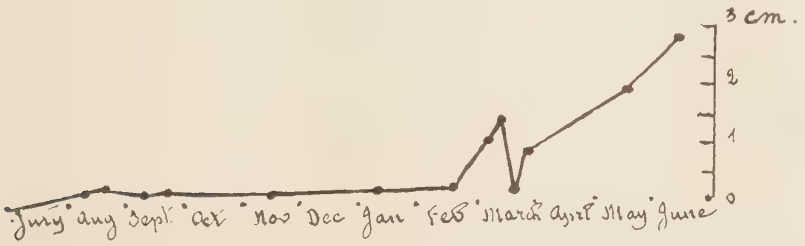

Fig. № II C. trompe

THE EFFECT OF OVIPOSITION ON REINDEER

The effect on reindeer is most marked. The animals are terrified by the attack; when the insect is hovering in front of their noses they assume a terror-stricken look, their eyes staring, their mouths open, and their bodies in a tensely strained attitude. When a reindeer is in this rigid state, the slightest touch on any part of the animal will cause muscular contractions which shake the whole body, just like an electric shock. When the insect deposits its larvae such a shock follows. It is succeeded by a total relaxation, the deer evidently realizing that it is not likely to be struck twice by the same insect. The animal appears nauseated and walks a few steps with its head elevated, sneezing and showing signs of nasal irritation.

GROWTH OF LARVAE IN THE HOST

Fig. II shows the rate of growth. It will be observed that for the first 8 months the larvae hardly grow at all, then suddenly there is a rapid growth during the last 4 months of their stay in the host. It

is difficult to account for this dormant state of the larvae during the winter, except that they are constantly exposed to cold air. When the rapid growth begins the weather is beginning to get warmer. The first larvae were seen to emerge on May 12th.

EMERGENCE OF LARVAE FROM THE NOSE

Reindeer suffer greatly when the larvae are leaving and are crawling out from the nostrils. The animals elevate their heads and sneeze, evidently trying to dislodge the grubs. But these expulsive attempts to get rid of the larvae are not violent, apparently through fear. "The expulsion of larvae was observed on several occasions, and almost invariably when a larva fell to the ground it was red in color, being coated with a thin film of blood."

PUPATION

After the larva has fallen to the ground it pupates rapidly, in five or six hours as a rule. It differs in this respect from *Oedemagena tarandi* which is much slower. The pupal period is shorter than it is for *Oe. tarandi.* According to Bergman (1917) the pupal stage may be 16-31 days. In observations made in Alaska, the pupal period lasted up to 56 days, but this was under adverse conditions and only 20 flies emerged out of a total of 54 pupae.

IMMUNITY

Absolutely nothing was learned about immunity to Cephenomyia. One point was noticed which should be taken into consideration by any one making counts of larvae in the heads of deer, which is, that reindeer fawns are very helpless against fly attacks, but older deer do their utmost to avoid the insect, and occasionally they seem to outwit it by either closing the nostrils or else by dodging the fly when it attempts to strike. The writer has seen flies leave animals alone after attempting to deposit larvae and failing to do so; they then go in search of another reindeer.

THE PREVENTION

Treatment is out of the question so that prevention is the only thing left. The constant movement of the herds should cause a diminution of flies. But the best way of all would undoubtedly be to provide darkened shelters for the deer. In some parts of Alaska this could easily be done.

In a previous paper (1922) the name *Cephenomyia nasalis* was proposed instead of *C. trompe.* This was owing to the writings of Railliet and Bequaert who apparently had proved that *Gastrophilus nasalis* was not a valid name and consequently Modeer's *C. trompe* was not valid either. Dr. Aldrich has recently cleared up the nomenclature, and

though *trompe* is evidently not the name Linnaeus intended to give the fly, *nasalis* will now be used for the horse bot, and the name *trompe* should be adhered to for reindeer, especially as it is in common use.

SUMMARY

The fly is on the wing from June to September. Reindeer are not so heavily parasitized with *C. trompe* as they are with Oedemagena.

C. trompe can make long flights like Oedemagena.

C. trompe when depositing its larvae causes more fear than *Oe. tarandi,* but few animals in a herd are attacked at one time owing to the lesser number of flies. Consequently it is more an individual attack and not one of the whole herd at once.

The larvae grow but little during the winter months, which may be partly due to cold; in the spring rapid growth takes place. The expulsion of grubs from the nose is a very painful process for reindeer.

Old reindeer resist the attacks of *C. trompe* better than young animals.

The constant moving of the herds should cut down the number of flies. Dark shelters would be ideal as a measure for the protection of deer.

ACKNOWLEDGMENTS

I am indebted to Dr. E. W. Nelson, Chief of the Bureau of Biological Survey for the generous help and support given during my stay in Alaska. In the preceeding pages occasional use has been made of passages previously published in the Bulletin on Reindeer.

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THE SPECIES OF MERMIS

A GROUP OF VERY REMARKABLE NEMAS INFESTING INSECTS

N. A. Cobb
U. S. Bureau of Plant Industry

HISTORICAL REVIEW

Apparently there are published records of at least two species of Mermis Duj., 1842: 1. The original type species of Dujardin, *Mermis nigrescens*. 2. The Mermis of Meissner, which may appropriately be called *Mermis meissneri* nom. nov. To these is now added a Mermis of certain grasshoppers of the northern and eastern United States and southern Canada, *Mermis subnigrescens,* n. sp.

One begins to suspect that Mermis Duj. will be found to include a very considerable number of forms in addition to those mentioned above. In fact it seems to the writer probable that some of them have been already reported, though usually referred to *Mermis nigrescens*.

The *M. nigrescens* Duj. of Meissner seems distinct from that of Dujardin. In neither case is the host known. Dujardin suspected his *M. nigrescens* to be from the larvae of the European Cockchafer, while Meissner did not know the host of his specimens and offered no surmise; hence one can as well as not regard the two collections as derived from different hosts. The descriptions of Dujardin and Meissner are not in harmony: Dujardin describes the eggs of his specimens as "noirs, globuleux," black and globular; Meissner describes the eggs as lenticular and brown. It is now needless to suggest error on the part of Dujardin on the basis of Meissner's words that "one seldom sees these lens-shaped eggs edgewise," for the eggs of *Mermis subnigrescens are globular*—showing that the eggs of a Mermis *can* be globular, and thus making it gratuitous to assume error on the part of Dujardin. It is noticeable that the tassels of the byssus of *nigrescens* as figured by Dujardin, are not so pronounced or so multifid as those shown in Meissner's illustrations. Meissner places the vulva near the middle of the body, while Dujardin in *nigrescens* notes the vulva as being far forward. Meissner was inclined to think Dujardin was in error in this respect; but Van Beneden described a species of Mermis, which he referred to *M. nigrescens* Duj., as depositing the eggs from a point not far from the head, thus apparently confirming Dujardin. It is noticeable that Meissner describes the profile of the oral elevations or "papillae" as

appearing the same in every direction, thus postulating an oral circlet of some sort. Dujardin mentions no such circlet.

Apparently, therefore, the two forms, that of Dujardin and that of Meissner, can be held identical only by more or less unwarrantably assuming a considerable number of errors on the part of reputable observers concerning matters comparatively easy of observation.

MERMIS DUJ. 1842

1. *Mermis nigrescens* Dujardin 1842. Type species.

2. *Mermis meissneri* nom. nov. Meissner 1855. Syn. *Mermis nigrescens* Duj. of Meissner.

3. *Mermis subnigrescens* n. sp.

0.08	0.54	?	41	48	99.5	126.mm
0.11	0.15	?		0.37	0.25	

These are the measurements of a female slightly above the average length, which is about 110 mm. Twenty-five females ranged in length

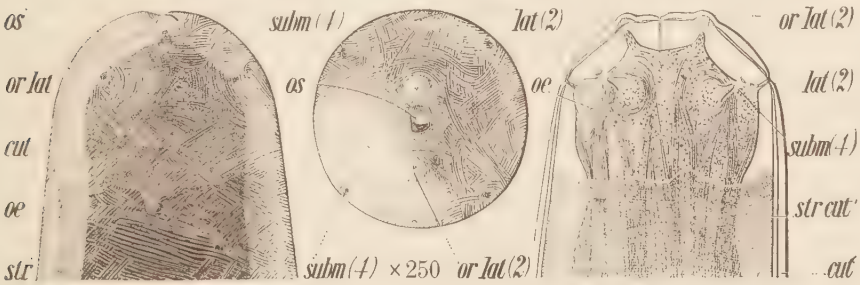

Fig. 1.—Side, front and median views of the head of *Mermis submigrescens* n. sp. *os,* mouth; *or lat,* lateral oral papilla; *cut,* cuticle; *oe,* oesophagus; *str,* striae; *subm,* submedian papilla; *lat,* lateral papilla. The side and front views are surface views, and are interpreted in terms of the oblique criss-cross fibers of the cuticle. The median view is a subcuticular view—more nearly an optical section.

from 67 mm. to 163 mm. The almost imperceptibly arcuate, convex-conoid posterior extremity tapers from opposite a faint, small, ventral, cuticular irregularity suggestive of an anal vestige, and is somewhat longer than the "anal" body diameter. There is sometimes a small but decided change or break in the oblique criss-cross fibers of the cuticle in the vicinity of the structure regarded as probably the vestigial anus. The form, size and color of the nema, as well as the number, position and *outward* form of the cephalic organs are as described by Hagmeier for the form referred by him to *M. nigrescens* Duj., except that the orange red cephalic pigment is diffuse and is located in the inner tissues rather than in the cuticle. (See Fig. 1.) The distribution and color of this cephalic pigment (absent in the males; probably because they have no

occasion to go above ground), strongly suggest, in view of the associated nerve tissues, that we have here an optical sense organ used in seeking favorable placement of the eggs, especially when comparison is made with the tropisms of the ovejector. *Subnigrescens* differs from *nigrescens* Duj. in having the vulva near the middle of the body instead of farther forward, the eggs brown instead of black, and with copious short-stemmed, branched and usually more or less dichotomous byssi, instead of longer-stemmed, simple, tassel-like byssi (see Fig. 2). The vulva, a quite decided feature midway on the body, is very slightly elevated and rather massive. The vagina (or better, possibly, the short tubular egg-ejector common to both uteri), extends inward two-thirds the way across the body, then turns, and, for a distance equal to the diameter of the body, lies in a longitudinal position. The subspherical eggs have somewhat the form of an ellipsoid of revolution, appearing subcircular in the polar view and circular in one equatorial view, but in the other equatorial view measuring about 38 x 48 microns.

Fig. 3.—Onchium or oral spear of the newly hatched larva of *Mermis subnigrescens* n. sp. The very sharp apex is usually held even with the front of the head, and the spear can be extruded for about half its length. *lum,* lumen of the onchium; *dir,* directing annular guide for the onchium; *bas,* three parted basal portion of the onchium, which makes a sharp distinction between Mermis and some other genera of the Mermithidae.

Females removed from the host and imprisoned alone undergo the final moult and develop their eggs parthenogenetically, producing perfect, active, infective embryos. The recently hatched larvae measure as follows:

Larva: 2.7 (2.8) ..... 11. (4.2) ..... 19. (5.) ..... 50. (juv.) (5.8) ..... 90. (3.5) ... 0.74mm

Rounded head- and tail-end similar, the latter the less tapering. Striae exceedingly difficult to resolve; contour entire. Trophosome lying in lat. 50-80, without lumen; its birefringent crystals very few, sometimes none (?), elongate, about 2μ long. Anus vestigal, usually only putative. Unicellular sexual anlage in lat. 60-65. Urocytes (?) in lat. 25-50, in four pairs, each pair moving into a tandem, occupying fully half the body width. Oesophagus slender, slightly enlarged at back, where it is one-fourth as wide as the corresponding part of the body.

Nerve-ring oblique; nervous tissue relatively voluminous. Finely granular glandular tissue alongside the urocytes (?) * significant in amount. Lateral chords half as wide as the body, consisting of two rows of cells except toward the ends.

The trophosome of the full grown nema tapers cephalad in the following fashion: while in most of the body it appears to occupy about half the diameter, at a distance from the head equal to 3 to 4 times the body diameter it tapers regularly forward, so that at the base of the neck, near where it ceases, it is one-fourth as wide as the body. Opposite the nerve ring there is to be seen a definite refractive cuticular marking on the ventral side, presumably representing the position of the excretory pore. This is the position it occupies in the newly hatched parasitic larva.

Male: $\frac{0.2}{0.3}$ ..... $\frac{0.6}{0.4}$ ..... $\frac{?}{?}$ ..... $\frac{-M-}{0.5}$ ..... $\frac{99.5}{21}$ $\frac{}{0.5}$ $_{12}$ **40.mm** The foregoing are the measurements of an apparently functional adult male Mermis taken from the soil by Mr. J. R. Christie at Woods Hole, Mass., June 14, 1926, on land where in the previous July practically every grasshopper was nematized, and almost exclusively by *subnigrescens*. (A second male specimen was 58 mm. long). These males agreed in structure with Hagmeier's two males taken by him from European grasshoppers (Stenobothrus, Decticus), the only other males of the genus Mermis Duj. this far seen. The rusty redness of the head tissues is almost totally absent in these males. What appeared to be viable, somewhat sole-shaped sperms, about 25 microns long, occurred in the sperm duct—their sole-shaped nuclei, 3 x 5½ x 17 microns, containing in the neighborhood of about a thousand regularly and closely packed spherical granules, considerably under one micron in diameter, reminding one not a little of the sperms of the free-living nemas of the genus Dorylaimus. Of the collection made from soil by Mr. Christie, in June, at Woods Hole, 2 out of 27 were males. It seems not unlikely that collections dug earlier in the year might have yielded a larger proportion of males.

From their form these males are presumed to be the mates of the above (at least sometimes, and perhaps usually, pathenogenetic) females, so commonly found a year earlier in grasshoppers at the same spot at Woods Hole.

Reasons for regarding the females of this form as distinct from *nigrescens* Duj. have already been suggested. Hagmeier's word "quastenförmig," and his reference to the correctness of the byssus-figures of Dujardin and Meissner, seem to favor the conclusion that the byssus on the eggs he saw was not like that on the eggs of *subnigrescens*. As he mentions no successful feeding experiments, it is presumed that his word "ziehen" is to be rendered "taken" or

* In two collections, tandem; doubtless arising from two cells.

"extracted," and not "bred," and that therefore the matching of his males and females rests on form alone—as here. May it be that his males should not be referred to *nigrescens* Duj., but rather to a new form (*subnigrescens*)? This query rests in part on the form of the egg-byssus of the supposed American mates. It is not yet known to what extent the byssus varies in the same species, but the variations noted by the writer in *subnigrescens* do not include, or approach very closely to, the "quastenförmigen" appendages of Dujardin, Meissner, von Linstow and (?) Hagmeier (see Fig. 1).

HABITAT

Common in the body cavity of various grasshoppers (identified by my colleague, A. N. Caudell, of the Bureau of Entomology, as *Melanoplus femur-rubrum* De Geer; *Stenobothrus curtipennis* Harris; *Chortophaga viridifasciata* De Geer; *Orphulella pelidne* Burm., *Encotolophus sordidus* Burm.) in Massachusetts, and no doubt in most of the other northern United States, and in southern Canada—in other words, more or less coextensively with the hosts.

In late summer or early autumn this Mermis leaves its host dead on the ground, and enters the soil, where several months later it moults and very slowly matures its hundreds of thousands of eggs, beginning to deposit them either the following season, or, probably more often, the second following season. Oviposition on the plants above is stimulated by moisture (rain), and particularly by light especially blue and near violet, and more or less by temperatures somewhat higher than those of the soil at the time. By obvious peristaltic action of the ovejector and uteri the eggs are expelled in batches of up to 15 to 20, at intervals of one to ten seconds, expulsion being stimulated remarkably by direct sunlight. Oviposition continues (reflex) after the head and central nervous system are seared off. Placing the laboring female, immersed in either warm (up to 30° Cent.) or cold water (even ice water) in a watch glass in direct sunlight causes a marked and almost instant acceleration in the action of the ovejector, and hence in the ovejection, which, however, soon ceases on placing the nema in darkness or deep shadow even if the temperature of the water be maintained. Ovejection in direct sunlight is little if any affected by the interposition of window glass or Crooke's glass (great reduction of ultraviolet rays); the action is gradually stopped by yellowish green glass known to cut out about 80 per cent of the heat of direct sunlight and by foliage (e. g. grape leaf) of similar color; is slowed and then stopped by dark ruby glass; but seems little interfered with by ordinary blue glass; indicating that in sunlight the more rapid visual rays in conjunction with a certain quan-

tity of direct heat rays stimulate ovejection. And these rough trials seem in accord with proved April (or early May) egg-deposition in lat. 41° north; notwithstanding the seasonal temperature, which is doubtless offset by means of direct sunlight. The inhibition due to yellowish green (foliage green) would ensure deposition of the eggs above the green shadows of the habitat and hence where they would be most likely to be taken in by grazing grasshoppers. Regular and normal deposition goes on sometimes at the rate of about 1,000 eggs per minute, at which rate in some cases the uteri might be fairly well emptied in the course of a spring morning in latitude 45°. The nema may make very slow weaving or serpentine motions of the whole body while depositing the eggs. Masses of eggs can be intermittently deposited even at a time when only a fraction of the trophosome has been consumed, and this, taken in conjunction with the facts mentioned above, leads to the conclusion that the eggs are not all deposited at one time, nor even in one season—something that would be in favor of the parasite in the not infrequent cases where the mermithisation is very high, and the hosts therefore largely killed off, and hence appear in reduced numbers the next season. Females after being on the surface of plants can, under favorable circumstances, make their way back into the moist soil in the course of fifteen to thirty minutes.

Most of these facts to a large extent justify the keenly reasoned out conclusions of Hagmeier, based on the then only partly known habits of Mermis.

While the three forms of Mermis treated here seem to differ from one another very materially, only further research can determine whether the names *nigrescens, meissneri* and *subnigrescens* should denominate specific, varietal, or, conceivably, only racial differences. For various reasons, among them registrational and economic-agricultural, as well as taxonomic, it seems simpler and better, and less likely to lead to confusion, to regard them, for the present, as specific.

REVIEW OF LITERATURE

In addition to the literature cited by Hagmeier 1912 see also Cobb, Steiner and Christie 1923, where by obvious inference Mermis is restricted to forms more closely related to that described in these pages, namely, by the removal to a new genus, Agamermis, of forms related to *Agamermis decaudata;* and particularly to Cobb, Steiner and Christie 1925, where the present species is denominated *"Mermis nigrescens* (or a closely allied form)," and where its life history is sketched.

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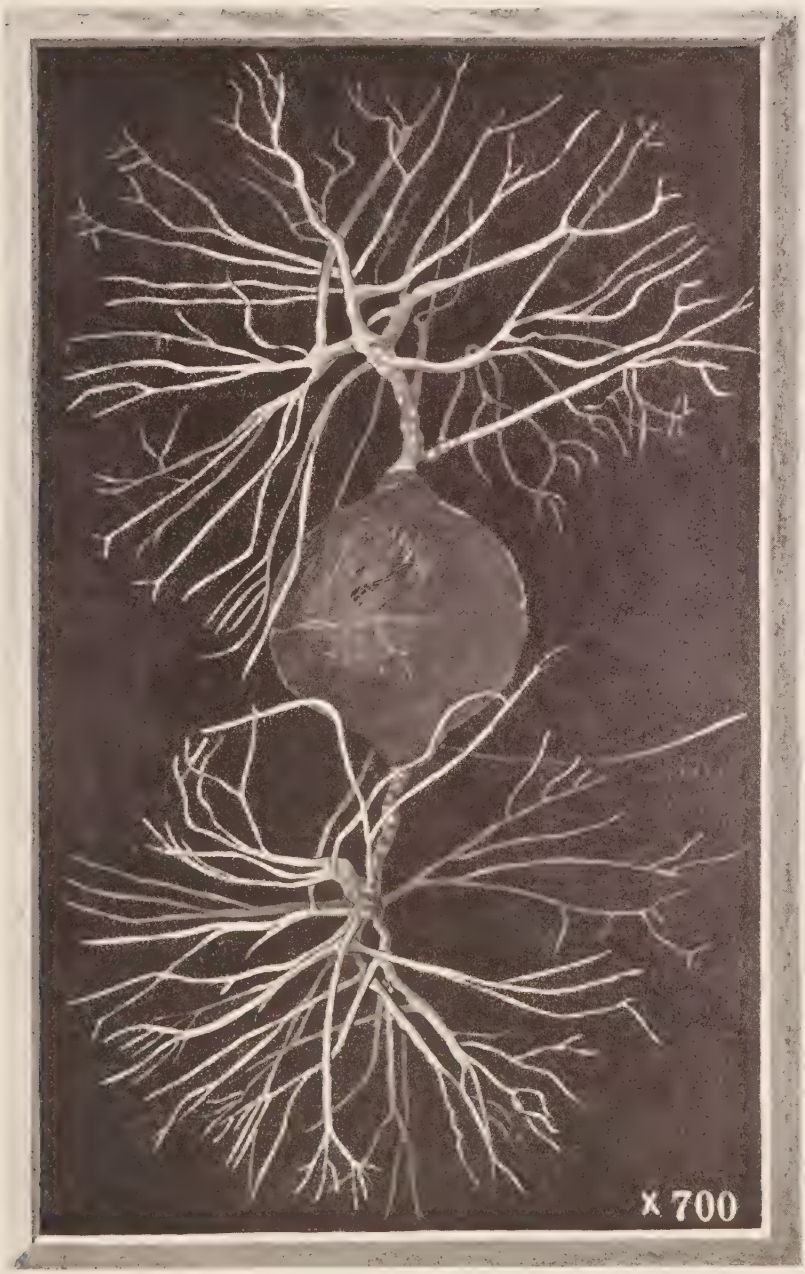

PLATE II

Fig. 2.—The brownish egg of *Mermis subnigrescens*. Viewed parallel to the plane of the paper the egg would appear slightly prolate. The very flexible branched entangling filaments arise from polar elevations. Midway is seen, faintly, the equatorial junction line of the hollow hemispherical halves of the thin egg-case, where the digestion fluid of the insect host acts so vigorously that the two halves of the egg-case soon separate, thus giving the fluid access to two opposite especially soluble places on the egg shell. The egg receives its case in the sexual duct. The head end of the larva is faintly to be seen; its oral spear, three-pronged at the back, is shown dark.

SKIN REACTIONS TO FRACTIONS OF THE TYPHOID BACILLUS*

HENRY J. NICHOLS AND JOSEPH W. SMITH, JR.
Medical Corps, U. S. Army

INTRODUCTION

Several years before his premature and much lamented death, Dr. Ransom discovered that he was sensitive to ascaris fluid. This finding led him into a study of skin reactions to various fractions of the fluid, and it is an evidence of the fine qualities of his mind and of the spirit of the real investigator, that a man who had previously devoted most of his life to the parasitic side of infection should boldly enter the field of the reactions of the host and make a substantial start on the solution of the complicated problems of sensitization. In 1924 Dr. Ransom, with W. T. Harrison and J. F. Couch, published a progress report of their work on "Ascaris Sensitization." At the close of the paper he stated that, as hogs and sheep are susceptible, "utilization of these experimental animals for studies on Ascaris sensitization may lead to results having an important bearing on the general problem of sensitization of human beings to foreign substances." The world of immunology, as well as that of parasitology, may have lost a leader!

Dr. Ransom had frequently discussed his findings and problems with one of us (N.) who was working at the same time on skin reactions as an evidence of immunity, especially in connection with typhoid vaccination. The relation of hypersusceptibility to immunity is still an unsettled question and one of us (N.) is inclined to consider them distinct. The connection of the following study with Dr. Ransom's work may, therefore, not be very close, but the two problems have at least something in common and we desire to call attention to Dr. Ransom's most recent intellectual attainments by planting a small tribute at the foot of his scientific monument. It is not a finished wreath, only a seedling; but it is offered with deep regard for the personality of our friend and with keen appreciation of his scientific abilities.

HISTORICAL REVIEW

The recent success of the use of skin tests in the detection of susceptibles and immunes to diphtheria and scarlet fever serves to emphasize the failure of the use of skin tests in other infectious diseases, such as typhoid fever. While the toxin-antitoxin skin reactions are fairly well understood in theory and are of definite value in practice, the

* From the Department of Laboratories, Army Medical School, Army Medical Center, Washington, D. C.

mechanism of bacterial skin reactions is baffling and the practical value in terms of immunity is nil.

In 1914 the subject of typhoid skin reactions was revived by Gay and his collaborators; they proposed the use of "typhoidin" as an index of immunity. In some observations on antityphoid vaccination, in 1915, one of the writers (Nichols) noted that "the local reactions under the skin seem to be more marked in some cases after typhoid fever and after vaccination. The explanation of these reactions involves complex questions. They may be regarded as evidences of true immunity or of sensitization or of endo-intoxication, according to one's conception of these complicated subjects." Nichols employed the typhoidin test of Gay, and found, as Gay had found, that positive reactions were obtained in a fairly large proportion of persons who had either had typhoid fever or been vaccinated. Nichols, however, regarded a positive reaction as evidence of typhoid protein sensitization, which he felt was not synonymous with true disease immunity. M'Kendrick (1923) reviewed the subject of skin tests in typhoid fever and described a method of testing for hypersensitiveness of the skin to organisms of the typhoid group. Using suspensions of unaltered bacilli he obtained positive reactions very constantly in patients suffering from typhoid fever and in chronic carriers. Nichols and Hitchens (1926) reported a number of tests made with weak dilutions of typhoid vaccine, given intracutaneously. Both the immediate and the late results of the injections were read and there was some correlation between the immediate skin reactions and general vaccination reactions. But their results were irregular and confusing when considered from the point of view of immunity in connection with a previous attack of the disease or with vaccination. They concluded that there were at least three factors to be considered, (1) allergic, (2) toxic, (3) nonspecific, including personal idiosyncrasy, and that these factors were so mixed up in the reaction that they defied the authors' analysis. They stated that progress might be made if fractions of the bacillus were isolated and studied separately. The present paper relates to this subject and some suggestive results have been obtained.

Recently Zinsser (1925), Avery (1925), Lancefield (1925), Heidelberger (1925), and their co-workers have demonstrated that the bacterial substance of the tubercle bacillus, the pneumococcus, the streptococcus, and the pneumobacillus may be fractionated into two separate portions, one of which they have called "P," the nucleoprotein, and the other "S," the soluble specific substance. Zinsser believes that the residue, or "S," "represents the haptophore group upon which specificity depends and which, in the simple process of solution, is disrupted from another substance together with which it represented a complete antigen in the antibody-forming sense." Avery, Heidelberger

et al have demonstrated that the residues of pneumococcus are polysaccharides, and they believe that the evidence so far accumulated favors strongly the view that "the polysaccharides isolated are the actual specific substances of pneumococcus." According to Avery, the isolated carbohydrate of pneumococcus is nonantigenic; the isolated protein is antigenic. Lancefield studied the immunological behavior of two cell constituents of nonhemolygic streptococci. She found that the so-called nucleoprotein is relatively nonspecific and gives rise to an antibody which shows group reactions with nucleoprotein of related species. She found by qualitative chemical tests that the other constituent was nonprotein. Her chemical examination indicated that it may be a carbohydrate.

EXPERIMENTAL METHODS

Dr. Zinsser kindly furnished us with some of his residues prepared from typhoid and paratyphoid bacilli, and we have also made some as follows: To a suspension of bacilli in distilled water (approximately 5,000 million per mil) is added 2 per cent of N/1 HCl solution. The preparation is steamed at 100 C. for one hour. It will be found to be partially cleared by this treatment, but it will not be a translucent solution. However, when 2 per cent of N/1 NaOH is then added and the preparation is agitated, it promptly clears up and it becomes evident that a true solution of the bacteria has been effected. Then to the neutral solution is added 0.5 to 1 per cent of N/1 $CH_3.COOH$ solution to reach the isoelectric point of the preparation which is about 4.5-4.6. The mixture is then shaken vigorously. An abundant flocculent precipitate forms almost instantaneously and settles very promptly. It may be completely removed by centrifuging, after which it may be again dissolved in slightly alkaline water, again precipitated, centrifuged, and redissolved ad infinitum. This constitutes the so-called "P" or nucleoprotein fraction." The supernatent fluid in the centrifuge tubes is filtered through paper and through a Berkefeld filter. It constitutes the "S" or "specific" soluble fraction. The volume in each case is made up to the original, the preparations are sterilized in the autoclave and preserved with 0.5 per cent phenol. For use, 1 in 10 dilution with buffered physiological salt solution has given reactions of about the right degree. The p_H values of the finished products are: Undiluted, "S" 4.6, "P" 8.4; diluted 1-10 with buffered salt solution, "S" 7.2, "P" 8.0. The exact chemical composition of our fractions is at present unknown. It is possible that they may not be pure, that is, "S" may still contain some "P," as in Zinsser's earlier work with tuberculin. "P" reacts faintly to the usual tests for protein, xanthoprotein, Millon's and biuret; "S" does not react. We have been unable to detect any trace of carbohydrate in either "S" or "P" by ordinary methods. The

nitrogen in "P" is really very small in amount; if there is any in "S" it must be almost infinitesimal.

We have employed our materials diluted 1 in 10 with buffered salt solution. The injections are intracutaneous. The amount injected has been 0.1 mil, usually; sometimes we have used 0.2 mil; 0.1 mil seems to be sufficient. The positive reaction to either "S" or "P" consists in erythema, infiltration, induration, local tenderness, discoloration, and gradual fading over a period of a week to ten days. The erythema becomes evident within four hours and increases to a maximum at from 20 to 30 hours. A 1-plus reaction presents an area of erythema about 1 cm. in diameter and with an elevation of several millimeters; a 2-plus reaction measures 2 cm. in diameter and is very distinctly elevated. We have seen even greater reactions. The induration becomes manifest on the second or third day and persists several days. Tenderness is appreciable at any time throughout the duration of the reaction. Discoloration occurs with the subsidence of the erythema as a purplish-brown stain which persists for a week to ten days. There is little or no general reaction.

TABLE 1.—*Incidence of the Typhoid "S" Skin Test*

	Total Number	Positive	Negative
Persons who have had typhoid fever and some of whom have had vaccine also	25	16 (64%)	9 (35%)
Persons who have not had typhoid fever but who have had typhoid vaccine	80	20 (25%)	60 (75%)
Persons who have not had typhoid fever nor any typhoid vaccine	53	4 (7.54%)	49 (92.46%)

The positive reactions were all 1-plus or greater; all reactions of less degree were recorded as negative.

We have done the typhoid "S" test thus far on 158 different persons and their reactions are grouped in Table 1. The typhoid "P" test has been used more recently and our data concerning it are not so full.

It is noted that a positive test occurs in a relatively high percentage of persons who have had typhoid fever. Of the 25 who have had typhoid fever, 8 had the disease between 1880 and 1900, that is, from 45 to 25 years ago; of those, 5 or 62.5 per cent, gave positive reactions. Sixteen had typhoid from 1901 to 1915, that is, from 25 to 10 years ago; of these, 11, or 68.75 per cent, gave positive reactions. One person had the fever in 1918; he gave a negative reaction. Likewise, a considerable but not a significant percentage of persons recently vaccinated gave a positive test.

As compared with the reactions obtained with the whole bacillus, an encouraging feature is the fact that 92 per cent of individuals who had not had typhoid fever or been vaccinated, gave a negative reaction. In other words, we have apparently, with the fraction, eliminated the

annoying toxic and nonspecific reactions which complicate the use of the whole bacillus.

The reaction is uniformly positive immediately after vaccination, but rapidly falls off as witness the data presented in Table 2. There are shown the incidence of the typhoid "S" skin test before and immediately after vaccination, again three weeks after vaccination and again six weeks after vaccination in a group of student nurses and junior aides, none of whom had had typhoid fever nor any typhoid vaccine previously.

TABLE 2.—*The Typhoid "S" Skin Test Before and After Vaccination. Three Doses of U. S. Army Typhoid-Paratyphoid Vaccine Were Administered the First on October 9, the Second on October 16, and the Third on October 23, 1925*

	Test Oct. 8, 1925		Retest on 17 Oct. 26, 1925		Retest on 20 Nov. 16, 1925		Retest on 12 Dec. 3, 1925	
No.	Pos.	Neg.	Pos.	Neg.	Pos.	Neg.	Pos.	Neg.
49	2 (4%)	47 (96%)	17 (100%)	0	16 (80%)	4 (20%)	6 (50%)	6 (50%)

Just how long the test stays positive after vaccination remains to be determined. It appears to vary much in different persons. Some of our positive reactions in vaccinated persons have been fully three years after the vaccination; some of our negatives have been less than three weeks after vaccination. We are not prepared at present to draw any final conclusions about the relation of these reactions to immunity.

TABLE 3.—*Typhoid and Paratyphoid "S" and "P" Reactions in a Group of Known Severe Reactors*

	Typhoid		Paratyphoid "A"		Paratyphoid "B"	
	"S"	"P"	"S"	"P"	"S"	"P"
M	2.	2.	1.5	2.	1.8	1.8
Sh	1.3	3.	1.5	2.5	2.5	3.3
St	1.5	2.	1.5	1.5	3.	2.5
H	2.5	1.7	2.	1.5	1.5	1.7
Sa	1.6	2.	1.2	2.	4.5	2.
R	4.	4.3	3.	3.	4.5	5.
E	1.6	1.7	1.6	1.7	1.1	1.2
Sm	2.	2.	2.	2.	2.5	3.
The figures in each case represent the diameter of the reaction in centimeters						
No. positive	8	8	8	8	8	8
Per cent positive	100	100	100	100	100	100
Average diameter of reactions expressed in centimeters	2.0	2.3	1.7	2.0	2.6	2.5

The reactions, however, can apparently be used to detect severe reactors to vaccination as is seen in Tables 3 and 4. In Table 3 are recorded the reactions of eight individuals all of whom previously on several different occasions had given strongly positive reactions to typhoid "S" and all of whom except one, M, react with more than ordinary severity to subcutaneous injection of typhoid-paratyphoid

vaccine. Three of the subjects, M, Sh and St, have not had typhoid fever; the other five have had the disease. On December 7, 1925, they were tested with various preparations as follows: Typhoid "S" and "P," paratyphoid alpha "S" and "P," and paratyphoid beta "S" and "P."

In every case recorded in Table 3 the reactions were 100 per cent positive. There were very little qualitative differences, if any, between the reactions to "S" and those to "P," and between the reactions to the same fractions of the different organisms. In all cases the reactions, both to "S" and to "P," passed through a series of color changes from fiery red to deep cherry and then to brown. In some cases there was a surrounding areola, several centimeters wide, of brownish-green discoloration, such as follows a bruise. The reactions persisted to a very pronounced degree for three days, during which time there were marked systemic symptoms in three of the subjects, Sa, R, and Sh, such as malaise, headache, feverishness, and diarrhea.

TABLE 4.—*Typhoid and Paratyphoid "S" and "P" Reactions in a Group of Known Mild Reactors*

	Typhoid		Paratyphoid "A"		Paratyphoid "B"	
	"S"	"P"	"S"	"P"	"S"	"P"
Br	1.	1.	1.	0.5	1.5	1.5
Bu	.2	5	.2	.5	.5	.5
C	1.	1.5	1.	1.2	1.2	2.
D	.2	.8	.2	.8	.2	.6
El	.5	.2	.4	.2	.3	.2
Ep	.2	.2	.2	.2	.2	.2
F	.8	1.	.6	.6	.8	1.
H	.8	1.5	.3	1.2	.6	1.5
J	1.	2.	.6	1.2	.5	2.
K	.4	.8	.2	.8	.2	.8
L	.2	.2	.2	.2	.2	.2
M	1.5	.2	1.5	.2	1.5	.2
Sa	.2	.2	.2	.2	.2	.2
Sc	1.	1.	.8	.6	.8	.6
St	.3	.3	.6	1.	.9	1.
V	1.	2.	.2	1.2	.2	2.
Y	.2	.2	.2	.2	.2	.2
The figures in each case represent the diameter of the reaction in centimeters						
No. positive	6	7	3	5	3	7
Per cent positive	35	41	18	29	18	41
Average diameter of reactions expressed in centimeters	.61	.8	.49	.63	.58	.86

In Table 4, on the other hand, are recorded the reactions of seventeen individuals none of whom when tested with typhoid "S" on Oct. 14, 1925, gave a positive reaction, and none of whom reacts more than ordinarily to subcutaneous injection of vaccine. On December 9, they were tested as were those of the preceding group, that is, with preparations of typhoid and paratyphoid "S" and "P." Only one of this group, Br, gives a history of typhoid fever; he says he had the disease in 1902. It will be noted that on December 9 he has given a positive reaction. None of the others have had the disease, but they all have had one or more courses of typhoid-paratyphoid vaccine. H. says he had a mild paratyphoid alpha infection in 1922.

One is struck at once with the marked contrast between the reactions presented by this group of mild reactors and those shown by the subjects of Table 3, the severe reactors. The average diameter of all reactions in mild reactors was .66 cm. while that of severe reactors was 2.7 cm. The differences are not entirely measurable in centimeters, either. The erythema is much less in degree and in some cases so faint as to be appreciable with difficulty and measured with even greater difficulty. It appears that the "P" fractions cause greater reactions than the "S" fractions in many cases. A comparison on December 11 of the skin reactions of the severe reactors tested on December 7 and recorded in Table 3 with those of the mild reactors tested on December 9 and recorded in Table 4 is illuminating. At the end of 96 hours every one in the first group still showed a very pronounced reaction at every point of injection. On the other hand, at the end of 48 hours only two of the second group, F and Sc, still showed plainly visible and mensurable reactions. In other words, the reactions in the second group were not only much less in extent but also far less in intensity and had completely or almost completely disappeared at the end of 48 hours, while those of the first group were still plainly visible at the end of 92 hours. The reactions recorded in Tables 3 and 4 would seem to indicate a relationship between skin reactivity to the fractions and reactivity to subcutaneous injection of the vaccine. The rapid disappearance of the reactions in mild reactors might be turned to account by reading the reactions at the end of 48 hours, rather than at the end of 24 hours.

SEROLOGICAL TESTS

Evidence of the presence of something specific and unique in typhoid "S" is found in its reaction with typhoid immune serum, as demonstrated by the contact precipitin test. For this purpose a very high-titer immune horse serum, prepared for the army in 1917 by the Rockefeller Institute, was used. Its agglutinin titer is about 1-100,000. The results are shown in Table 5.

TABLE 5.—*Precipitin Tests with Typhoid Immune Serum and Fractions of the Typhoid and Paratyphoid Bacilli*

Incubation: 1 hour at 37 degrees C. and 18 hours in refrigerator.

Typhoid		Paratyphoid "A"		Paratyphoid "B"	
"S"	"P"	"S"	"P"	"S"	"P"
++	—	—	—	—	—

Four rabbits were injected with three doses of the typhoid fractions, two with "S" and two with "P." The first dose, 0.5 mil, was subcutaneous; the second and third, 0.5 and 1.0 mil, respectively, were

intravenous. The interval between doses was 7 days. Seven days after the third dose the rabbits were bled. A normal animal was bled at the same time. Precipitin tests were set up with all five sera, as follows: 1st tube, "S"; 2nd tube, "P"; 3rd tube, Berkefeld filtrate of typhoid vaccine; 4th tube, salt solution containing 0.5 per cent phenol. This control was used because both "S" and "P" were preserved with phenol in that concentration. The reactions in tubes 1, 3 and 4 in every case were absolutely negative. In tube 2 for some unknown reason in every case there was a precipitate at the line of contact, quite as marked with the normal serum as with the others. These reactions are shown in Table 6.

TABLE 6.—*Precipitin Tests with Typhoid Fractions and the Sera of Rabbits Injected with the Typhoid Fractions*

Incubation as in table 5.

Animal No.	Injected with	1 Typhoid "S" Undiluted	2 Typhoid "P" Undiluted	3 Berkefeld Filtrate of Whole Typhoid Vaccine	4 Salt Solution with 0.5% Phenol
150	Typhoid "P"	—	..	—	—
155	Typhoid "P"	—	..	—	—
157	Typhoid "S"	—	..	—	—
158	Typhoid "S"	—	..	—	—
Normal	Untreated	—	..	—	—

The sera of the same four rabbits, 150, 155, 157, and 158, were examined for agglutinin content against the whole organism. The results were absolutely negative. The same sera were then diluted 1 in 3 and tested again in contact precipitin tests against "S" and "P," this time in increasing dilutions from 1-1,000 to 1-10,000. The tubes were incubated as usual. Absolutely no precipitate was seen in any of the tubes. These experiments indicate that in the doses and manner used typhoid "S" and "P" are not antigenic.

An experiment to determine the toxicity of the preparations for rabbits was then performed. Five rabbits were injected intravenously on Dec. 30, 1925, with 5 mils of material—Nos. 141, 142, and 151 with "S"; 140 and 154 with "P." None of them showed any ill effects. We have repeatedly demonstrated that our official typhoid-paratyphoid vaccine is fatally toxic in doses of 5 mils per kilo of rabbit; in fact it frequently kills in doses of 4 mils per kilo. Each mil of typhoid "S" represents the specific soluble substance of 5,000 million bacilli; each mil of typhoid "P" represents the nucleoprotein of 5,000 million bacilli; therefore, 5 mils of "S" or "P" may be compared with 25 mils of typhoid-paratyphoid vaccine for the purposes of this experiment. On Jan. 14, 1926, each animal again received 5 mils intravenously, this time as follows: Nos 141, 142 and 154, "S"; 151 and 140, "P." Observe that No. 154, which was injected with "P" originally, this time

received "S"; on the other hand No. 151, originally injected with "S," received "P." Each animal showed an immediate and very transient reaction, consisting of twitching and trembling, as though having a chill. The reaction in each case was all over in less than one minute, after which the animal appeared to be somewhat lethargic. This experiment indicates that in the doses and manner used typhoid "S" and "P" are not as toxic as the whole bacilli nor are they efficient sensitizers.

SUMMARY

A skin reaction has been obtained with the "S" fraction of the typhoid bacillus. The reaction occurred in only 4 per cent of persons who have never had typhoid fever or typhoid vaccine, in 100 per cent of persons within three days of the last dose of typhoid vaccine (course of three doses at intervals of one week), in 80 per cent of persons within three weeks of the last dose, in 50 per cent within six weeks of the last dose, in 20 per cent of persons who have had typhoid vaccine at some time within three years, and in 64 per cent of persons who have had typhoid fever, some as long as 45 years ago. The toxic and non-specific reactions obtained by the use of the whole bacillus seem to be eliminated by the use of this fraction.

The reaction to "P" has not been studied to the same extent as that to "S." However, individuals who react to "S" appear also to react to the same or even greater degree, and persons who do not react to "S" appear not to react to "P" either. Hence, the differential significance of the fractions is still in doubt. The results in general are suggestive of sensitization reactions, but the subject is so new and complicated that no final conclusions are warranted at this time. Further purification may result in different reactions to "P."

Skin reactions to "S" and "P" are definitely correlated with severe vaccination reactions and might be used to detect especially susceptible individuals.

A brief study of the antigenic value of the fractions in rabbits has seemed to demonstrate that typhoid "S" and "P" are not antigenic, but "S" gives a precipitin reaction with strong antityphoid serum while "P" does not. Neither fraction appears to be toxic for rabbits in fairly large doses.

The object of this work in general was to obtain further information on the relation of skin reactions to immunity and hypersusceptibility. It is believed that some light has been thrown on these problems and further work is indicated.

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PROCEEDINGS OF THE HELMINTHOLOGICAL SOCIETY OF WASHINGTON, NINETY-THIRD TO NINETY-SIXTH MEETING

It is appropriate that the Ransom Memorial Number of the Journal of Parasitology should contain the records of several meetings of the Helminthological Society of Washington. Dr. Ransom was an active member of the society from the time of its organization in 1910, its president from 1919 to 1920, and its representative in the Washington Academy of Sciences from 1923 until his death. His loyalty and active interest have been important factors in the growth and development of the society.

The ninety-third meeting was held on February 20, 1926. Dr. Stiles gave an informal talk on the late Dr. Charles A. Pfender, a charter member of the Helminthological Society, who died February 17, 1926.

Dr. W. A. Hoffman reported a case of Fasciola in the throat of an Armenian living in Haiti. Dr. Hoffman's note was discussed by Dr. Stiles who traced the history of the discovery of this affection, noting that it was discovered by a pupil of Professor Blanchard. Treatment consists in administering an emetic.

Dr. Hoffman also reported a case of a planarian feeding on the larvae of Culex and noted that only one previous case of the sort had been recorded.

Dr. Stoll presented a note on the development of hookworm eggs from decayed female specimens based on observations made by him in Porto Rico.

Dr. N. A. Cobb called attention to nematodes from the gut of *Phlebotomus argentipes* forwarded to him by Dr. Asa Chandler from India. Dr. Chandler found the gut of a male swarming with eggs and larvae, but he found only two adult worms containing eggs. Dr. Cobb suggested that the larvae may be non-parasitic.

Dr. Benjamin Schwartz reported the occurrence of *Spirocerca sanguinolenta* in a dog in North Dakota, this being the first record of the occurrence of this species in the northern part of the United States. *S. sanguinolenta* has been reported from the United States on very few occasions. It was collected and reported by Sommers in 1896 in one out of 50 dogs examined in the District of Columbia. It was collected and reported from the dog by Curtice but no data were given. Specimens from the dog collected at Atlanta, Ga., in 1902, are present in the Helminthological Collection of the Bureau of Animal Industry. Specimens were collected from a lynx (*Lynx canadensis*) in the National Zoological Park at Washington, D. C., by Graybill in 1906. This parasite has also been reported from the dog in Alabama by Haythorn Ryan in 1917. Recently Dr. E. W. Price forwarded to the Bureau of Animal Industry several specimens of this species collected by him from the esophagus of a dog in College Station, Texas., in 1922.

Dr. Schwartz also reported the occurrence of the nodular worm *Bourgelatia diducta* in swine in Mauke, Cook Island, South Seas. The specimens were forwarded by Dr. S. M. Lambert of the International Health Board. *B. diducta* was described by Railliet, Henry, and Bauche in 1919 from swine in Annam, Indo-China, and has not been reported since that time, the present report being the second record of the occurrence of this species.

Dr. Schwartz also presented a note on the specific identity of whipworms from swine. These worms have been generally considered a valid species (*Trichuris suis*) morphologically distinct from other species of the genus Trichuris. Recent studies by him have shown, however, that *T. suis* is morphologically indistinguish-

able from the whipworm occurring in man (*T. trichiura*). He stated that a study of the literature has shown, moreover, that the name *T. suis* was proposed by Schrank (1788) on the basis of a brief record by Goeze who reported whipworms from a wild pig without giving adequate morphological data concerning the worms. Creplin (1825) was not convinced that *T. crenatus* Rud., a synonym of *T. suis,* was morphologically distinct from *T. dispar* Rud., a synonym of *T. trichiura,* a view which was also shared by Leuckart. Schneider's morphological differentiation between *T. trichiura* and *T. suis* does not appear to be valid, and the two species are morphologically identical. The name *T. suis* becomes a synonym of *T. Trichiura.*

Dr. Schwartz called attention to the fact that the description of *Oesophagostomum dentatum* by Railliet, Henry, and Bauche (1919) corresponds to the description of *O. longicaudum* Goodey 1925. Railliet, Henry, and Bauche describe the oesophagus as being swollen at the anterior end, the spicules as being from 775 to 850 μ long, and the tail of the female as being from 400 to 500 μ long. These characters are the basic morphological features on which *O. longicaudum* is based.

The ninety-fourth meeting was held on March 20, 1926.

Dr. D. Sinitsin of New York City, formerly professor of zoology in the University of Moskow, presented the following paper:

METHODS I HAVE FOLLOWED IN MY RESEARCH

In the methods of scientific research there are two different questions to consider: First, the deriving or looking for the theme and, second, the treating of the theme. I shall speak on these two phases. The entire content of a scientific theme may be condensed into the sum of facts which are to be learned and the idea which is to bind all these facts together. Each of these elements of the theme—fact or idea—if taken up separately is worth, scientifically, nothing; it is only when the two are logically connected that we have a good scientific theme. The scientific value of a theme depends almost exclusively on the character of the idea and not on the facts. The ideas may be narrow or wide, foolish or wise, unsuccessful or successful, and at the same time the facts appear to be beyond such characteristics, being only more or less attainable, from the technical point of view. Therefore there are in the world no bad themes, as far as the material is concerned. Let us remember, for example, how scarce and unattainable was the material which Newton had in his possession: An apple falling from a tree above onto the earth, and the planets of the solar system in the cosmos, and what a great and beautiful idea has tied these plain and commonly known facts together! Therefore I believe that each of us who engages in studying cestodes, trematodes, or nematodes has the possibility of discovering and establishing laws which control life on the earth.

Even though we know that a theme is good, it may be difficult for this theme to be expressed. Happy ideas are conceived very seldom; there are very few brains able to bring them forth. This is true particularly in the present age, the source of our themes, the great biological theories of the past age, having been exhausted. President Butler of Columbia University says that "something between 75 and 90 percent of what is called research in the various universities and institutes of the land is not research at all, but simply the rearrangement or reclassification of existing data or well-known phenomena" (N. Y. Times, Dec. 31, 1925). If President Butler's characterization of American scientific work is correct, it must be true also with reference to other countries. Where formerly European professors gave to the young students of their staff a wealth of themes on which to work, in the present day these same professors have not themes even for themselves. As to how to find a good theme, I can tell nothing but of my own experience. The theme of my first work, when I was an undergraduate student of the University of Warsaw, was given me by my professor of zoology; it was entitled: The Endoparasite Worms of Birds and Mammals of the District of Warsaw, and contained, among the rest, descriptions of new species and genera of Cestoda. My first publication which was based entirely on my own idea was

"Materials to the Natural History of Trematoda," with the subtitle "Distoma of Frogs and Fishes of the District of Warsaw" (1905). At that time I was entirely under the influence of Semper's idea of the relation between organism and environment. I conceived the idea of studying the life of inhabitants of any limited space in as great detail as possible; the discovery of the life cycle of some trematode was my first aim. Unfortunately, however, I was forced to suspend work on this subject in changing from Warsaw to Moskow, but I must acknowledge that this theme has not yet lost its alluring charm for me, and whenever I see a pool with its inhabitants there is revived in my mind the same wish as formerly. At that precise time another idea had come into my head—it was a strange, almost a crazy idea, that digenetic trematodes, in regard to their relationship, are more closely connected with coelomate worms and arthropods than with acoelomate ones, and that the sporocysts and redia are the very forms which may help us in restoring, or determining, the structure of the free-living ancestor. This idea was the basis of my work of 1911, which deals with sporocysts, redia, and cercaria from the snails of the Black Sea.

Consider for a moment that almost miraculous phase of a working idea, that is, its creative power. I share the opinion of some scientists who believe that it is better to get a wrong idea than to have none. A new idea, like magic eyeglasses, enables an investigator to see sides and points of commonly known facts that no one else has seen before. For example, I once asked a distinguished histologist to look over my preparations of the muscles of the tail of a cercaria and to give me his opinion of them. After a careful examination of the preparation he said, "I see nothing but plain muscle fibers of Platoda." "But they are striped," said I. "It is impossible," rejoined he, but after having resumed his examination he exclaimed: "Strange! Why did I not perceive them from the first? You are right; they are striped." This incident illustrates that unless I had had this idea, however questionable it was, that there was a possibility of striped muscles in Trematoda, and accordingly was looking for them, I should never have seen them. Thanks to the same idea, I discovered additional new facts in the structure of redia and cercaria.

Research which is based on a wrong or false idea may sometimes become very useful for the idea against which it was directed. The best example of this may be found in Pasteur's works. We all know his extensive experiments proving the impossibility of spontaneous generation, but there are few men, even among bacteriologists, who know that Louis Pasteur believed in spontaneous generation and during all his life tried to prove it. He wrote in 1871: "Now, twenty years have passed in the course of which I have pursued, without success, the search for life which was not preceded by life. The results of such a discovery would be innumerable; natural history, medicine, physiology would have received a greater impulse than ever before. Therefore when I learn that some one of the happier searchers has forestalled me, I dash on him with all my strength to destroy his assertions" (T. Costantin, "Origin de la vie sur le globe." Paris, 1923). With this as an example, I have not feared odd, even crazy, ideas when they occurred to me; on the contrary I welcome them. Nevertheless, it is advisable not to publish such an idea until it has been fortified with a sufficient number of facts. I learned this from experience, having published, when only a beginner in the field of research on Trematoda, a short article in which I boldly expressed, without sufficient basis, my crazy idea of the relationship of digenetic Trematoda. The immediate reaction to this was the dedication to me by Dr. Odhner, whose name is well known to all of us, of a very heated article in which he vigorously attacked me for expressing such an idea.

Now let us consider the question of treating the theme. The first condition, I am inclined to affirm, is a deep and strong belief in the idea on which the theme is based. The idea must completely fill my mind so that during that time I see things only through that idea and, as a result, it rewards me with new facts. Such a belief must not be blind; if the facts contradict it, it must be thrown away and everything destroyed that was constructed with its help. The practical program

of scientific research may be presented in the form of three consecutive phases: Studying the literature of the subject, building up one's own view of the subject and, lastly, experimentation. During the first stage of the work, studying the literature, I apply severe and dire criticism. There is no authority who is considered incapable of error, and thus I work out the way to my own view. Let me illustrate with some examples from my experience. When I was studying the literature of the life history of *Distoma cygnoides,* it seemed at first that all was right, but after continued critical reading I succeeded in showing that the assertion of authorities that *Cercaria macrocerca,* after losing its tail, creeps actively into the cloaca of a frog, was based on nothing else than bare supposition. I discovered that there was a Libellula which transported the young *Distoma cygnoides* to the intestine of a frog, and that the large tail of *Cercaria macrocerca* served as a bait to be caught by the carnivorous larva of Libellulidae. The circumstances which led me to throw light on some dark points in the life history of the liver fluke were somewhat similar; only a critical studying of Thomas' and Leuckart's works on this subject had helped me to do that. Another thing to be kept in mind is that the prestige of such men as Leuckart is so great that the authors of textbooks are inclined to consider as facts not only what was really a fact but also what was expressed by this great man as only a supposition. Therefore I always try to learn things from their original source.

To proceed, after I have formed my own opinion of the subject and have constructed my own theory or idea, I then make preparations for the experiment. This means that I build in my own imagination the most detailed design of the future experiment. I should like to emphasize this step to you because of its great importance. If an experiment is insufficiently thought over and is undertaken hurriedly, it can by its failure destroy the root of a possibly sound idea. It is true that special ability of the imagination is required, a scientific imagination which deals with the facts of reality. My method of designing the detailed picture of the future experiment may be briefly characterized by the one word, "reincarnation." It means that I treat my cercaria, redia, snails and so on, as a novelist treats the heroes of his future novel; that is, I put myself in the place of a cercaria or of a larva of Libellula and fancy how I would act as such. I am sure that if Conan Doyle were not a novelist, he would be a famous parasitologist. Without joking, I confess that I have derived much benefit from reading his excellent detective novels. For example, I present you the picture of the way in which I worked out the plan of experiments on the cercaria of the liver fluke: "I am now a cercaria which has just emerged from its cyst and has found itself in the intestinal tract of a sheep. On me are poured smart, biting fluids from the digestive glands and I wish nothing more than to escape this horrible place. . . . What am I to do? If I were smaller, I should penetrate into a blood vessel but I am too big for that; Dr. Leuckart advises me to look for the opening of the gall duct in the duodenum, but while I am listening to him I am transported far behind this opening and how can I, in such a spacious hollow filled with moving food, find that commended spot? I do not accept this advice; I hasten to conceal myself any place; I work my way into the bottom, between the folds of the epithelium and penetrate through the intestinal wall." The picture is finished. The work of the imagination is over. Now the experiment: I feed a rabbit encysted cercaria; after a lapse of time I open its abdominal cavity, pour in cold water and then rinse out the water into a glass cup and at the bottom of it I find the young Distoma or liver fluke. The experiment is over!

I should not wish any one to think I wish to teach others with my experience; each person has his own method of reasearch, but I think, at the same time, that the psychological side of scientific research is of no less importance than the experimental one, though usually much less discussed. I have hoped, therefore, that a consideration of this phase might be useful for us.

Dr. Sinitsin's paper was discussed by Drs. Stiles and Cobb.

Dr. Chapin presented the following notes:

Eustrongylides ignotus Jagersk. in the United States.—This species, previously known from *Ardea coco* Linn. and *Botaurus pinnatus* Licht. collected in Brazil by

Natterer, is represented in the National Collection by two lots, one of which is composed of larvae. The first lot consists of several specimens representing both sexes, taken from the fat around the gizzard of *Ardea herodias,* near Washington, D. C. Dec. 5, 1923, collected by E. A. Chapin. These specimens are adult and fit the excellent description of Jagerskiold's *Eustrongylides ignotus* in all particulars. The second lot collected on Eastern Branch, Washington, D. C., July 15, 1925, by Bartsch and Reid, consists of many specimens of a fish, *Fundulus diaphanus,* each fish containing from one to three specimens of an immature nematode. These worms are in the preadult stage and the characters of the adult worm may be seen within the last cuticle. A comparison of the posterior extremities of two males, one adult and one larval, leaves no doubt of their specific identity.

The ninety-fifth meeting was held at the residence of Dr. Stiles on April 17, 1926. Dr. H. J. Nichols acted as chairman and Dr. M. C. Hall acted as secretary in the absence of Dr. Schwartz.

Dr. M. C. Hall presented the following note:

Dirofilaria immitis vomited by a dog.—A nematode was sent in to the Zoological Division this month by Dr. Charles S. Chase of Bay Shore, N. Y., with a note to the effect that it was vomited by a dog suspected of having an infestation with *D. immitis;* this specimen proved to be a female *D. immitis,* 23.5 cm. long and somewhat macerated.

A casual survey of the literature indicates that Leidy reported the vomiting of 2 specimens of this worm by a dog, and that the worm has been reported from the stomach, esophagus, trachea, liver, posterior vena cava and thoracic cavity, and encysted in subcutaneous and intermuscular connective tissue, as well as from the normal site in the right heart and pulmonary artery.

The precise reason for the occurrence of the worm in these unusual situations does not appear to have been ascertained. It might be assumed that when an adult worm dies it is swept into the arterial terminations of the pulmonary circulation and lodges as an embolus. Here it might disintegrate, but under certain circumstances it might cause pressure necrosis resulting in a breaking down of tissues with the release of the worm to the air passages or to the thoracic cavity. In the former case the worm might be brought up the air passages by coughing as a result of the irritation in the necrotic area and the presence of a foreign body in the air passages, the passage upwards being aided by the ciliated epithelium of the lungs. Once in the mouth the worm might be ejected or might be swallowed and vomited; in either case it would probably be regarded as having been vomited. The presence of the worm in the liver or in subcutaneous and intermuscular cysts suggests that in these cases an adult worm has either broken from the arterial circulation in the lungs into the venous circulation and has lodged somewhere along the systemic circulation, or that an infective larva has somehow failed to gain the usual site in the heart or pulmonary artery and has developed in the unusual situation.

In discussion, Dr. Stiles suggested the possibility of the dog having eaten the infested heart of another dog. Dr. Cobb reported that he had found this worm in a wild fox in Massachusetts and raised the question as to the earliest age at which dogs were infested. Dr. Stoll also discussed the paper.

Dr. C. W. Stiles and Miss A. J. Speer reported upon "A specimen of feces from Gorilla species" forwarded by Dr. R. N. Greene, of Jacksonville, Florida. The intestinal parasites thus far recorded from Gorilla are: *Troglodytella gorillae, Ancylostoma duodenale, Necator americanus, N. congolensis, Oesophagostomum stephanostomum,* "Strongylus" *falcatus, Libystrongylus hebrenicutus,* and *Ascaris lumbricoides.*

The specimen in question contained: Large cysts of Endamoeba species (closely allied to, if not identical with, *E. coli*); cysts of a ciliate, possibly Troglodytella; eggs of some Strongyloides, genus and species not definitely determined;

eggs of Trichuris species; a larval nematode resembling, if not identical with, Diplogaster.

Dr. Stiles presented "A consideration of certain recently published views on cases of light hookworm infection" (to be published elsewhere) which resulted in considerable discussion by Doctors Cobb, Cort, Hall, Stoll, Thomson and others.

Miss A. J. Speer presented the following note:

Leptomonas michiganensis, a new name for the American *Crithidia fasciculata.*—In preparing a compendium of the Parasites of Mosquitoes the flagellate protozoa have offered considerable difficulty. As for instance, the following may be cited:

In 1902 Léger described a flagellate species from Europe, under the name *Crithidia fasciculata,* found in the intestine of adult, larval and pupal Anopheles and Culex. In 1907, Novy, MacNeal and Torrey reported what they believed to be the same species from American mosquitoes (Culex), collected at Ann Arbor, Michigan. Later authors, especially Woodcock (1914), and Thomson and Robertson (1925), consider that the parasite of Novy, MacNeal, and Torrey is specifically distinct from that described by Léger and they transfer the American species to the genus Leptomonas, but they retain for it the old specific name *fasciculata.* Attention is invited to the point that this procedure is contrary to Articles 35 and 36 of the International Code. To continue the specific name *fasciculata* for the Ann Arbor species, in view of the taxonomy just mentioned, will inevitably result in confusion, and in order to inhibit this latter, I here introduce the name *michiganensis* for the form reported by Novy, MacNeal, and Torrey (1907), and designate *Culex pipiens* as type host with Ann Arbor, Michigan, as type locality for the protozoon.

The paper was discussed by Dr. J. G. Thomson of the London School of Tropical Medicine. Dr. Cobb asked as to the advisability of naming a parasite after a country or other locality, to which Dr. Stiles replied that it was ordinarily advisable as helping to fix the type locality, but inadvisable in naming a pathogenic form as it might prove economically injurious to a locality to do so.

Dr. Cobb discussed the species of Rhabdias occurring in Bufo spp. and a salamander. There appear to be several species of the genus, and existing specific descriptions are usually inadequate. Adults and larvae were examined for the presence of amphids, and these were found in the adult. More studies are necessary to ascertain whether the *R. bufonis* used by Boveri and others in a study of the chromosomes were actually *R. bufonis.* In connection with the topic, Dr. Cobb advises that the word rhabditoid be used in referring to the larvae now usually called rhabditiform.

Dr. Stoll raised the question as to the value of the hemoglobin index in uncinariasis, to which Dr. Stiles replied that the symptoms were often nervous or that only constipation might be evident, and that in the nervous symptoms the memory was less affected than the ability to perform mathematical operations. Dr. Thomson noted the inadequacy of the hemoglobin index owing to the fact that there was a rapid regeneration of red cells and the index did not indicate blood destruction but only the status as established by the balance between destruction and regeneration, a thing varying with individuals as well as with the number of worms present.

Dr. Cobb noted a statement by Dr. White of New Orleans that he had found a failure to develop sexually among boy and girl hookworm patients in New Orleans.

BENJAMIN SCHWARTZ, *Secretary.*

The ninety-sixth meeting was held May 15, 1926, Dr. Hall acting as chairman. The following officers were elected for the ensuing year:

President.....Dr. Benjamin Schwartz
Recording Secretary.....Mr. J. R. Christie
Corresponding Secretary.....Miss A. J. Speer

In discussing the value of mercurochrome as an anthelmintic, Dr. Hall stated that doses of this drug removed about 80 per cent of the whipworms from dogs, but was less effective against hookworms and tapeworms. He expressed the opinion that if mercurochrome proves valuable as an anthelmintic, it will be against whipworms. Due to its staining power, one can determine the extent to which it has reached and penetrated parasites, a fact which may prove useful to the laboratory in studying the action of anthelmintics. Andrews recalled that fine strains of *Bacillus coli* had been grown on cultures containing 2½ per cent mercurochrome.

Dr. Justin M. Andrews presented the following note:

The specificity of the Isospora of cats and dogs with respect to host.

In 1923, Wenyon concluded that, "There occur in cats and dogs three species of coccidia of the genus Isospora, namely, *Isospora felis* n. sp., *Isospora rivolta* (Grassi 1879), and *Isospora bigemina* (Stiles 1891)," which he distinguishes on the basis of the size of the oocysts. He makes no specific distinctions as regards the host. The literature to which he refers indicates that each size species occurs in both cats and dogs. In this laboratory we have seen the two larger forms, *I. felis* and *I. rivolta* in both cats and dogs although *I. bigemina* has been encountered only in the cat. No precise biometrical data have as yet been produced to indicate that oocysts of similar size ranges from the two different hosts do have statistically equivalent mean dimensions.

Another method of testing the specificity of these parasites is to find out whether or not they are mutually cross-infective. The work of Böhm (1923) seems to indicate that they are not. He fed some of the same batch of oocysts that had proved to be infective to a mongrel dog, to a kitten and a man. Though the feces of both these experimental animals were examined for a month, no oocysts were found. To one of two 2-months old fox-terrier puppies, he fed oocysts (*I. felis*) on three consecutive days. The other dog was kept for a control animal. The feces of both animals were examined for 67 days after the first feeding, but oocysts were never found in either. These experiments strongly suggest that there are two different kinds of parasites per size species, the one of which is infective to cats but not to dogs, and vice versa.

My own observations on this point encompass some infections which occurred incidental to experiments designed for other objectives, and a few deliberate attempts to infect dogs and cats with cat and dog oocysts, respectively.

In all, 8 dogs received oocysts of feline origin of one or both of the two larger species of Isospora. The fecal examinations of the first 6 were by the smear method. Two of these animals showed infection parasitologically, though the attacks were mild, and of the remaining 4, 3 showed clinical evidence (diarrhea) of infection, though no oocysts were found in their feces. The fecal examinations of the last 2 were by the D. C. F. method, and both were positive clinically and parasitologically. One cat was inoculated with oocysts from a dog and showed a typical, though somewhat belated, case of coccidiosis clinically and parasitologically. Thus of 8 dogs and one cat inoculated with cat and dog oocysts respectively, 4 dogs and the cat showed conclusive parasitological evidence of infection, and of the 4 remaining dogs, 3 showed a somewhat suggestive clinical sign which might have been confirmed parasitologically had the D. C. F. method of diagnosis been employed in the examination of their stools. It is suggested that Böhm's negative results may be due either to his method of examination of feces or the fact that he may have used animals that had been previously infected and were, therefore, immune.

These data indicate that at least two species of the cat and dog Isospora are cross-infective, and thus support the morphological evidence that they are of the same relative species.

In discussion, Dr. Stiles pointed out that the dog is the type host of *Isospora bigemina* and that this parasite is very common in the United States, having been found repeatedly in the vicinity of Baltimore and Washington.

Dr. E. A. Chapin presented the following note:

In a recent publication, Harrah offers a table of measurements to substantiate his assertion that *Collyriclum faba* (Brems.) and *C. colei* Ward are specifically distinct. Nevertheless, there is only one character in the list given that the author does not admit to be variable to such an extent that no separation of the two species can be possible. This character relates to the extent of the vitellaria. In the European form, the vitellaria are said to be always symmetrical and to be composed of 6, 7, or 8 groups of follicles on each side. The American material studied shows from 5 to 7 groups on the left and from 7 to 9 groups of follicles on the right side of the worm. Through the kindness of Prof. Dr. L. Szidat of Konigsberg, a specimen of the European form has been received for study and in this specimen the vitellaria are asymmetrical, there being 6 groups on the left and 9 groups on the right side. There can be no doubt that the European form is as variable as the American form and hence there can be no possible reason to continue to recognize the two as specifically distinct. As all American records of this parasite are later than the date of the introduction of the English sparrow, it is probable that it was introduced into this country with that host.

Dr. N. A. Cobb presented the following notes: 1. Nemic diseases of narcissus. 2. The species of Mermis.

Dr. Steiner presented the following notes:

1. Remarks about the occurrence of *Aphelenchus neglectus* Rensch in wheat, cotton and grape-vine roots in the U. S. A.

2. Remarks about the plant parasitic nature of *Hoplolaimus coronatus* Cobb.

3. Observations upon the ability of some so-called soil nemas to locate germinating corn seedlings in a water column at a distance of 30-50 cm.

4. Contrary to other nemas, Mermithids are quite resistant to injuries. Cut parts of Mermithids, if kept free from bacterial or fungus infection, might live for a long time. The body near the wound is transformed into a brownish-yellow amber-like substance. A female which was beheaded back of the nerve ring in the early part of July, 1925, is still living and producing eggs (July 9, 1926). Similar observations have been made with other specimens.

5. Observations on the number of specimens of *Tylenchus dipsaci* a plant may harbor. A small leaf of a Chinese primrose infested with this parasite was submerged for 24 hours in water. All the specimens that were able to leave the plant tissues moved into the water; their lowest estimated number being between 50,000 and 60,000.

J. R. CHRISTIE, *Secretary.*

The actual dates of issue of Volume XII of THE JOURNAL were as follows:

No. 1, November 10, 1925.
No. 2, December 28, 1925.
No. 3, April 29, 1926.
No. 4, August 5, 1926.